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URANIUM AND GEOLOGY[1]

INTRODUCTION

IN our day but little time elapses between the discovery and its application. Our starting-point is as recent as the year 1903, when Paul Curie and Labord showed experimentally that radium steadily maintains its temperature above its surroundings. As in the case of many other momentous discoveries, prediction and even calculation had preceded it. Rutherford and McClung, two years before the date of the experiment, had calculated the heat equivalent of the ionization effected by uranium, radium and theorium. Even at this date (1903) there was much to go upon, and ideas as to the cosmic influence of radio-activity were not slow in spreading.[2]

I am sure that but few among those whom I am addressing have seen a thermometer rising under the influence of a few centigrams of a radium salt; but for those who pay due respect to the principles of thermodynamics, the mere fact that at any moment the gold leaves of the electroscope may be set in motion by a trace of radium, or, better still, the perpetual motion of Strutt's "radium clock," is all that is required as demonstration of the cease-

[1] Address of the president of the Geological Section of the British Association for the Advancement of Science, Dublin, 1908.

[2] See letters appearing in *Nature* of July 9 and September 24, 1903, from the late Mr. W. E. Wilson and Sir George Darwin referring to radium as a solar constituent and one from the writer (October 1, 1903) on its influence as a terrestrial constituent.

less outflow of energy attending the events proceeding within the atomic systems.

Although the term "ceaseless" is justified in comparison with our own span of existence, the radium clock will in point of fact run down, and the heat outflow gradually diminish. Next year there will be less energy forthcoming to drive the clock, and less heat given off by the radium by about the one three-thousandth part of what now are evolved. As geologists accustomed to deal with millions of years, we must conclude that these actions, so far from being ceaseless, are ephemeral indeed, and that if importance is to be ascribed to radium as a geological agent, we must seek to find if the radium now perishing off the earth is not made good by some more enduringly active substance.

That uranium is the primary source of supply can not be regarded as a matter of inference only. The recent discovery of ionium by Boltwood serves to link uranium and radium, and explains why it was that those who sought for radium as the immediate offspring of uranium found the latter apparently unproductive, the actual relation of uranium to radium being that of grandparent. But even were we without this connected knowledge, the fact of the invariable occurrence in nature of these elements, not only in association but in a quantitative relationship, can only be explained on a genetic connection between the two. This evidence, mainly due to the work of Boltwood, when examined in detail, becomes overwhelmingly convincing.

Thus it is to uranium that we look for the continuance of the supplies of radium. In it we find an all but eternal source. The fraction of this substance which decays each year, or, rather, is transformed to a lower atomic weight, is measured in tens of thousands of millionths; so that the uranium of the earth one hundred million years ago was hardly more than one per cent. greater in mass than it is to-day.

As radio-active investigations became more refined and extended, it was discovered that radium was widely diffused over the earth. The emanation of it was obtained from the atmosphere, from the soil, from caves. It was extracted from well waters. Radium was found in brick-earths, and everywhere in rocks containing the least trace of demonstrable uranium, and Rutherford calculated that a quantity of radium so minute as 4.6×10^{-14} grams per gram of the earth's mass would compensate for all the heat now passing out through its surface as determined by the average temperature gradient. In 1906 the Hon. R. J. Strutt, to whom geology owes so much, not only here but in other lines of advance, was able to announce, from a systematic examination of rocks and minerals from various parts of the world, that the average quantity of radium per gram was many times in excess of what Rutherford estimated as adequate to account for terrestrial heat-loss. The only inference possible was that the surface radium was not an indication of what was distributed throughout the mass of the earth, and, as you all know, Strutt suggested a world deriving its internal temperature from a radium jacket some 45 miles in thickness, the interior being free from radium.[3]

My own experimental work, begun in 1904, was laid aside till after Mr. Strutt's paper had appeared, and valued correspondence with its distinguished author was permitted to me. This address will be concerned with the application of my results to questions of geological dynamics.

Did time permit I would, indeed, like to dwell for a little on the practical aspect of measurements as yet so little used or under-

[3] *Proc. R. S.*, LXXVII., p. 472, and LXXVIII., p. 150.

stood; for the difficulties to be overcome are considerable, and the precautions to be taken many. The quantities dealt with are astoundingly minute, and to extract with completeness a total of a few billionths of a cubic millimeter of the radio-active gas—the emanation—from perhaps half a liter or more of a solution rich in dissolved substances can not be regarded as an operation exempt from possibility of error; and errors of deficiency are accordingly frequently met with.

Special difficulties, too, arise when dealing with certain classes of rocks. For in some rocks the radium is not uniformly diffused, but is concentrated in radio-active substances. We are in these cases assailed with all the troubles which beset the assayer of gold who is at a loss to determine the average yield of a rock wherein the ore is sporadically distributed. In the case of radium determinations this difficulty may be so much the more intensified as the isolated quantities involved are the more minute and yet the more potent to affect the result of any one experiment. There is here a source of discrepancy in successive experiments upon those rocks in which, from metamorphic or other actions, a segregation of the uranium has taken place. With such rocks the divergences between successive results are often considerable, and only by multiplying the number of experiments can we hope to obtain fair indications of the average radio-activity. It is noteworthy that these variations do not, so far as my observations extend, present themselves when we deal with a recent marine sediment or with certain unaltered deposits wherein there has been no readjustment of the original fine state of subdivision, and even distribution, which attended the precipitation of the uranium in the process of sedimentation.

But the difficulties attending the estimation of radium in rocks and other materials leave still a large balance of certainty—so far as the word is allowable when applied to the ever-widening views of science—upon which to base our deductions. The emanation of radium is most charactertistic in behavior; knowledge of its peculiarities enables us to distinguish its presence in the electroscope not only from the emanation of other radio-active elements, but from any accidental leakage or inductive disturbance of the instrument. The method of measurement is purely comparative. The cardinal facts upon the strength of which we associate radium with geological dynamics, its development of heat and its association with uranium, are founded in the first case directly on observation, and, in the second, on evidence so strong as to be equally convincing. Recent work on the question of the influence of conditions of extreme pressures and temperatures on the radio-active properties of radium appear to show that, as would be anticipated, the effect is small, if indeed existent. As observed by Makower and Rutherford, the small diminution noticed under very extreme conditions in the γ radiation possibly admits of explanation on indirect effects. These observations appear to leave us a free hand as regards radio-thermal effects unless when we pursue speculations into the remoter depths of the earth, and even there while they remain as a reservation, they by no means forbid us to go on.

The precise quantity of heat to which radium gives rise, or, rather, which its presence entails, can not be said to be known to within a small percentage, for the thermal equivalent of the radio-active energy of uranium, actinium and ionium, and of those members of the radium family which are slow in changing, has not been measured directly. Professor Rutherford has supplied me, however, with the calculated amount of the aggregate heat energy liberated per second by all these bodies. In

the applications to which I will presently have to refer I take his estimate of 5.6×10^{-2} calories per second as the constant of heat-production attending the presence of one gram of elemental radium.

To these words of introduction I have to add the remark, perhaps obvious, that the full and ultimate analysis of the many geological questions arising out of the presence of radium in the earth's surface materials will require to be founded upon a broader basis than is afforded by even a few hundred experiments. The whole sequence of sediments has to be systematically examined; the various classes of igneous materials, more especially the successive ejecta of volcanoes, fully investigated. The conditions of entry of uranium into the oceanic deposits has to be studied, and observations on sea-water and deep-sea sediments multiplied. All this work is for the future; as yet but little has been accomplished.

THE RADIUM IN THE ROCKS AND IN THE OCEAN

The fact first established by Strutt that the radium distributed through the rock materials of the earth's surface greatly exceeds any permissible estimate of its internal radio-activity has not as yet received any explanation. It might indeed be truly said that the concentration of the heaviest element known to us (uranium), at the surface of the earth is just what we would not have expected. Yet a simple enough explanation may be at hand in the heat-producing capacity of that substance. If it was originally scattered through the earth-stuff, not in a uniform distribution but to some extent concentrated fortuitously in a manner depending on the origin of terrestrial ingredients, then these radio-active nuclei heating and expanding beyond the capacity of surrounding materials would rise to the surface of a world in which convective actions were still possible and, very conceivably, even after such conditions had ceased to be general; and in this way the surface materials would become richer than the interior. For instance, the extruded mass of the Deccan basalt would fill a sphere 36 miles in radius. Imagine such a sphere located originally somewhere deep beneath the surface of the earth surrounded by materials of like density. The ultimate excess of temperature, due to its uranium, attained at the central parts would amount to about 1,000° C., or such lesser temperature as convective effects within the mass would permit. This might take some thirty million years to come about, but before so great an excess of temperature was reached the force of buoyancy developed in virtue of its thermal expansion must inevitably bring the entire mass to the surface. This reasoning would, at any rate, apply to material situated at a considerable distance inwards, and may possibly be connected with vulcanicity and other crustal disturbances observed at the surface. The other view, that the addition of uranium to the earth was mainly an event subsequent to its formation in bulk, so that radio-active substances were added from without and, possibly, from a solar or cosmic source, has not the same *a priori* probability in its favor.[4]

I have in this part of my address briefly to place before you an account of my experiments on the amounts of radium distributed in surface materials. Here, indeed, direct knowledge is attainable; but this knowledge takes us but a very few miles inwards towards the center of the earth.

The Igneous Rocks.—The basalt of the Deccan, to which I have referred, known to cover some 200,000 square miles to a depth of from 4,000 to 6,000 feet or more, appears to be radio-active throughout. A

[4] *Nature*, LXXV., p. 294.

fine series of tunnel and surface specimens sent to me by the Director of the Indian Geological Survey has enabled me to examine the radio-activity at various points. It is remarkable that the mean result does not depart much from that afforded by a long series of experiments on north of Ireland basalt and on the basalt of Greenland.

Again, the granites and syenites—and those of Mourne, Aberdeen, Leinster, Plauen, Finsteraarhorn have been examined—while variable, yet approximate to the same mean result.

In the Simplon and St. Gothard tunnels igneous rocks have been penetrated at considerable depth beneath the surface. The greatest true depth is attained, I think, in the central St. Gothard massif. It is remarkable, and may be significant, that in these rocks I have reached the lowest radio-activities I have met—down to almost one billionth of a gram of radium per gram; although the general mean of the St. Gothard igneous rocks, owing to the high radio-activity of the Finsteraar granite at the north end of the tunnel, is not exceptionally low. Radio-active minerals seem common in the Simplon rocks, involving considerable variations in successive experiments. Some of the highest results are omitted on the mean given below, but as it is difficult to know what to allow for purely sporadic radium the mean is not very certain. In the case of a specially high result I asked Professor Emil Werner to determine the uranium: my result was confirmed. My list of mean results on igneous rocks up to the present is the following:

Basalts (14)	5.0[5]
Granites (6)	4.1
Syenites (1)	6.8
Lewisian gneiss (3)	5.7
Simplon (32)	7.6
St. Gothard (32)	5.1

The general mean is 6.1.

From the igneous rocks have originated the sediments after a toll of dissolved substances has been paid to the ocean. It does not of course follow necessarily that the percentage of radium, or more correctly of uranium, in the sedimentary rocks should be less than in the igneous. The residual materials might keep the original percentage of the parent rock, or even improve upon it. There are reasons for believing, however, that there would be a diminution.

Those sedimentary rocks which have been derived from materials formerly in solution offer a different problem. In their case there is little or none of the original materials carried into the secondary rock, and the radio-activity will depend mainly upon how far uranium is precipitated or abstracted with the rock-making substances. In other words, upon how far the waters of the ocean will restore to the rocks what it has borrowed from them.

This brings me to consider the condition of the ocean as preparatory to quoting experiments on the sediments.

The Ocean and its Sediments.—The waters of the ocean, covering five sevenths of the earth's surface to a mean depth of 3.8 kilometers, represent the most abundant surface material open to our investigation. As the mean of a very large number of experiments upon twenty-two different samples of sea-water from various widely separated parts of the ocean, I obtain a mean of 0.016×10^{-12} gram per cubic centimeter. There is considerable variability. Taking the mass of the ocean as 1.458×10^{18} tonnes, there must be about 20×10^{9}

[5] This number is to be multiplied by 10^{-12}, and represents billionths of a gram of radium per gram of material investigated. Throughout the rest of my address this understanding holds, unless where a different meaning is specified. The numbers in parentheses signify the number of different specimens investigated.

grams (20,000 tons) of radium in its waters.

The experiments which I have been able to make on deep-sea deposits, thanks mainly to the kind cooperation of Sir John Murray, apply to ten different materials of typical character.

The results are so consistent as to lead me to believe that although so few in number they can not be far wrong in their general teaching.

The means are:

	Radium	Extension: Millions of Square Miles
Globigerina ooze	7.2	49.5
Radiolarian ooze	36.7	2.5
Red clay	33.3	51.5

Diatom oozes have not yet been examined.

It is apparent from these results that the more slowly collecting sediments are those of highest radio-activity, as if the organic materials raining downwards from the surface of the ocean carried everywhere to the depths uranium and radium abstracted from the waters; but in those regions where the conditions were inimical to the preservation of the associated calcareous tests, there was the less dilution of the radio-active substances accumulating beneath. The next table shows that radio-activity and the percentage of calcareous matter in these deposits stand in an inverse relation:

			Calcium Carbonate, Per Cent.	Radium
Globigerina ooze,	*Chall.*,	338	92.24	6.7
Globigerina ooze,	"	296	64.34	7.4
Red clay,	"	5	12.00	15.4
Red clay,	"	276	28.28	52.6
Radiolarian ooze,	"	272	10.19	22.8
Radiolarian ooze,	"	274	3.89	50.3

The percentages of calcium carbonate are from the report of the *Challenger* Expedition. The red clay in the table, which reads as an apparent exception, is probably a case of recent change in the character of the deposit, for the evidence of manganese nodules and sharks' teeth brought up with this clay is conclusive as to the slow rate of its collection. Readers of Sir John Murray's and Professor Renard's report will remember many cases where recent change in the character of a deposit is to be inferred.

A point of much importance in connection with our views on oceanic radio-activity is that of the presence in the waters and in the deposits of the parent radio-active substance, uranium. The evidence that the full equivalent amount of uranium is present is, I believe, conclusive.

In the first place, to so vast a reservoir as the ocean the rivers can not be supposed to supply the radium sufficiently fast to make good the decay. In a very few thousand years, in the absence of uranium, the rivers must necessarily renew almost the entire amount of radium present. I have made examination of the water of one great river only—the Nile. The quantity of radium detected was 0.0042×10^{-12} per cubic centimeter. That is less than the oceanic amount. In short, it is evident that the uranium must accumulate year by year in the oceanic reservoir, like other substances brought in by the rivers, and that the present state of the waters is the result of such actions prolonged over geological time.

While this reasoning is conclusive as regards the waters of the ocean, it does not assure us that the sediments accumulating in their depths are throughout as radio-active as their surface parts would indicate. There might be a precipitation of radium unattended by uranium, in which case their deeper parts would not be radio-active.

Against this possibility there is the evidence of such true deep-sea deposits as were formed in past times and to-day still preserve their radio-activity. For instance, the chalk, which, considering that it

was undoubtedly a very rapidly formed deposit, exhibits a radio-activity quite comparable with that of the *Globigerina* oozes, deposits which it most nearly resembles. In this deposit, clearly, the uranium must have collected along with the calcareous materials. We can with security argue that the similar oozes collected to-day must likewise contain uranium. In the case of the red clays we have the direct determination of the uranium which Professor Emil Werner was so good as to make at my request. Considering the difficulties attending its separation, the result must be taken as supporting the view that here, too, the radium is removed from the uranium. Regarding the efforts of other observers to detect uranium in such deposits, it is noteworthy that without the guidance of the radium, enabling specially rich materials to be selected for analysis, the success of the investigation must have been doubtful. The material used was a red clay with the relatively large quantity of 54.4 billionths of a gram per gram. In a few grams of this Werner obtained up to seven twelfths of the total theoretic amount, and of course the separation of the uranium is not likely to have been complete.

It might be thought a hopeless task to offer any estimate of the total bulk of the sub-oceanic deposits, and from this to arrive at some idea of the quantity of radium therein contained. Nevertheless, such an estimate is not only possible but is based on deductions which possess considerable security. As a major limit I believe the estimate of the total mass of deposit is unassailable, and such deductions as might be applied will still leave it an approximation to the truth.

The elements of the problem are simple enough; we know that the sedimentary rocks have been derived from the igneous, some 30 per cent. of the latter entering into solution in the process of conversion. Some of the soluble constituents, owing to their great solubility, have remained in solution since they entered the ocean.[6] These are the salts of sodium. An estimate of the amount of these salts in the ocean gives us a clue to the total amount of rock substance which has contributed to oceanic salts and oceanic deposits since the inception of the oceans. Some years ago I deduced on this basis that the igneous rocks which are parent to the sodium in the sea must have amounted to about 91×10^{16} tons.[7] This figure in no way involves the rate of supply by the rivers, or our estimate of geological time. It only involves the quantity of sodium now in the ocean—a fairly well-known factor—and the loss of this element, which occurs when average igneous rocks are degraded into sedimentary rocks—a factor also fairly well known. Mr. F. W. Clark, to whom geological science is indebted for so much exact investigation, has recently repeated this calculation, using data deduced anew by himself, and arrives at the result that the bulk of the parent igneous rock was 84.3×10^6 cubic miles.[8] On a specific gravity of 2.6 my estimate in tons gives nearly the same result: 84×10^6 cubic miles.

Now about one third part of this parent rock goes into solution when breaking up into a detrital sediment. The limestones upon the land are part of what was once so brought into solution. Having made deduction of these former marine deposits (and I here avail myself of Van Hise's and Clark's estimates of the total amount of the sedimentaries and the fraction of these which are calcareous),[9] and, allowing for

[6] *Trans. Royal Dublin Soc.*, Vol. VII., Ser. II., pp. 23 ff.

[7] *Ibid.*, p. 46.

[8] "The Data of Geochemistry," by F. W. Clark, p. 29.

[9] *Ibid.*, p. 31.

the quantity remaining in solution in the ocean, the result leaves us with the approximation of twenty million cubic miles of matter once in solution, and now for the greater part existing as precipitated or abstracted deposits at the bottom of the ocean. We are to distribute this quantity over its floor. If the rate of collection had been uniform in every part of the ocean throughout geological time, a depth of about one seventh of a mile (240 meters) of deposit would cover the ocean bed.

While, I believe, we can place considerable reliance on this approximation, we are less sure when we attempt an estimate of its mean radio-activity. If we assume for it an average radio-activity similar to that of *Globigerina* ooze, we find that the quantity of radium involved must be considerably over a million tons. Apart from the value which such estimates possess as presenting us with a perspective view of the great phenomena we are dealing with, it will now be seen that it supports the finding of the experiments on sedimentary rocks, and leads us to anticipate a real difference in the radio-activity of the two classes of material.

The Sedimentary Rocks.—The radium content of those of detrital character is indicated in the following sandstones, slates and shales:

Shales, sandstones, grits (10)	4.4
Slates (Cambrian, Devonian)	4.7
Mud from Amazon	3.2

Some of the above are from deep borings in Carboniferous rocks (the Balfour and Burnlip bores),[10] and from their nature, where not actually of fresh-water origin, can owe little to oceanic radio-activity. Many of the following belong to the class of precipitates, and therefore owe their uranium wholly or in part to oceanic source:

Marsupites chalk	4.2
Green sandstone	4.9
Green sand (dredged)	4.5
Limestones and dolomites [Trenton, Carboniferous, Zechstein, Lias, Solenhofen (7)]	4.1
Keuper gypsum	6.9
Coral rock, Funafuti bore (4)[11]	1.7
Trias-Jura sediments, Simplon: 17 rocks of various characters	6.9
Mesozoic sediments, St. Gothard: 19 rocks of various characters	4.2

The general mean of sixty-two rocks is 4.7.

Making some allowance for uncertainties in dealing with the Simplon rocks, I think the experiments may be taken as pointing to the result:

Igneous rocks from 5 to 6.

Sedimentary rocks from 4 to 5.

If our estimate of oceanic radium be applied to the account of the sedimentary rocks in a manner which will be understood from what I have already endeavored to convey, there will be found to exist a fair degree of harmony between the great quantities which we have found to be in the sediments of the ocean and the impoverishment of the sediments which the experiments appear to indicate.

In all these results fresh and unweathered material has been used. The sand of the Arabian desert gave me but 0.4. Similarly low results have been found by others for soils and such materials. These are not to be included when we seek the radio-activity of the rocks.

As regards generally my experiments on the radium-content of the rocks, I can not say with confidence that there is anything to indicate a definite falling off in radio-activity in the more deeply seated materials I have dealt with. The central St. Gothard

[10] For these rocks, and for much other valuable material, I have to thank Mr. D. Tate, of the Scottish Geological Survey.

[11] For these I have to thank the trustees of the British Museum and Mr. A. S. Woodward, F.R.S.

and certain parts of the Deccan have given results in favor of such a decrease. On the other hand, as will be seen later, the granite at the north end of the St. Gothard and the primitive gneiss of the Simplon show no diminution. According to the view I have put forward above as to the origin of the surface richness in radium it is I think to be expected that, while the richest materials would probably rise most nearly to the surface, there might be considerable variability in the radio-activity of the deeper parts of the upper crust.

URANIUM AND THE INTERNAL HEAT OF THE EARTH

While forced to deny of the earth's interior any such richness in radium as prevails near the surface, the inference that uranium exists yet in small quantities far down in the materials of the globe is highly probable. This view is supported by the presence of radium in meteoric substances and by its very probable presence in the sun—that greatest of meteorites. True, the radio-thermal theory can not be supposed to account for any great part of solar heat unless we are prepared to believe that a very large percentage of uranium can be present in the sun, and yet yield but feeble spectroscopic evidence of its existence. Taken all together, the case stands thus as regards the earth. We are assured of radium as a widely distributed surface material, and to such depths as we can penetrate. By inference from the presence of radium in meteoric substances and its very probable presence in the sun, from which the whole of terrestrial stuff probably originated, as well as by the inherent likelihood that every element at the surface is in some measure distributed throughout the entire mass, we arrive at the conclusion that radium is indeed a universal terrestrial constituent.

The dependent question then confronts us—Are we living on a world heated throughout by radio-thermal actions? This question—one of the most interesting which has originated in the discovery that internal atomic changes may prove a source of heat—can only be answered (if it can be answered) by the facts of geological science.

I will not stop to discuss the evidence for and against a highly heated interior of the earth. I assume this heated interior the obvious and natural interpretation of a large class of geological phenomena, and pass on to consider certain limitations to our knowledge which have to be recognized before we are in a position to enter on the somewhat treacherous ground of hypotheses.

In the first place, we appear debarred from assuming that the surface and central interior of the earth are in thermal connection, for it seems certain that, since the remote period when (probable) convective effects became arrested by reason of increasing viscosity, the thermal relations of the surface and interior have become dependent solely on conductivity. From this it follows if the state of matter in the interior is such as Lord Kelvin assumed—that is, that the conductivity and specific heat may be inferred from the qualities of the surface materials—we have remained in thermal isolation from the great bulk of the interior for hundreds of millions of years, and perhaps even for more than a thousand million of years. Assuming a diffusivity similar to that of surface rocks, and starting with a temperature of 7,000° Fahr., Kelvin found that after 1,000 million years of cooling there would be no sensible change at a depth from the surface greater than 568 miles. In short, even if this great period—far beyond our estimates of geological time—has elapsed since the *consistentior status*, the cooling surface

has as yet borrowed heat from only half the bulk of the earth.

It is possible, on the other hand, that the conductivity increases inwards, as Professor Perry has contended; and if the central parts are more largely metallic, this increase may be considerable. But we find ourselves here in the regions of the unknown.

With this limitation to our knowledge, the province of geothermal speculation is a somewhat disheartening one. Thus if with Rutherford, who first gave us a quantitative estimate of the kind, we say that such and such a quantity of radium per gram of the earth's mass would serve to account for the 2.6×10^{20} calories which, according to the surface gradients, the earth is losing per annum, we can not be taken as advancing a theory of radio-active heating, but only a significant quantitative estimate. For, in fact, the heat emitted by radium in the interior may never have reached the surface since the convective conditions came to an end.

And here, depending upon the physical limitations to our knowledge of the earth's interior, a possibility has to be faced. That uranium is entirely absent from the interior is, as I have said, in the highest degree unlikely. If it is present, then the central parts of the earth are rising in temperature. This view, that the central interior is rising in temperature, is difficult to dispose of, although we can adduce the evidence of certain surface-phenomena to show that the rise in temperature during geological time must be small or its effects in some manner kept under control. In a word, whether we assume that the whole heat-loss of the earth is now being made good by radio-active heating or not, we find, on any probable value of the conductivity, a central core almost protected from loss by the immense mass of heated material interposed between it and the surface, and within this core very probably a continuous source of heat. It is hard to set aside any of the premises of this argument.[12]

We naturally ask, Whither does the conclusion lead us? We can take comfort in a possible innocuous outcome. The uranium itself, however slowly its energy is given up, is not everlasting. The decay of the parent substance is continually reducing the amount of heat which each year may be added to the earth's central materials. And the result may be that the accumulated heat will ultimately pass out at the surface by conductivity, during remote future times, and no physical disturbance result.

The second limitation to our hypotheses arises from this transformation and gradual disappearance of the uranium. And this limitation seems as destructive of definite geothermal theories as the first. To understand its significance requires a little consideration. The fraction of uranium decaying each year is vanishingly small, about the ten thousand-millionth part; but if the temperature of the earth is maintained by uranium and consequently its decay involves the fall in temperature of the whole earth, the quantity of heat escaping at the surface attendant on the minute decrement would be enormous. An analogy may help to make this clear. Consider the case of a boiler maintained at a particular temperature by a furnace within. Let the combustion diminish and the furnace temperature fall a little. The whole mass of the boiler and its contents follow the downward movement of temperature, heat of capacity escaping at the surface. An observer, only noting the outflow of radiated heat and unable to observe

[12] Professor H. A. Wilson has made a suggestive estimate of the thermal effects of radium enclosed in the central parts of the earth (*Nature*, February 20, 1908).

the minute drop of temperature, would probably ascribe to the continued action of the furnace, heat which, although derived from it in the past, should no longer be regarded as indicating the heating value of the combustion. Magnify the boiler to terrestrial dimensions: the minutest fall in temperature of the entire mass involves immense quantities of heat passing out at the surface, which no longer indicate the sustaining radio-thermal actions within.

It is easy to see the nature of the difficulties in which we thus become involved. In fact, the heat escaping from the earth is not a measure of the radium in the earth, but necessarily includes, and for a great part may possibly be referred to, the falling temperature, which the decay of the uranium involves. If we take λ (the fraction of uranium transforming each year) as approximately 10^{-10} and assume for the general mass of the earth a temperature of 1,500°, a specific heat of 0.2, and, taking 6×10^{27} as its mass in grams, we have, on multiplying these values together, a loss in calories per annum of 1.8×10^{20}. This by hypothesis escapes at the surface. But the surface loss, as based on earth-gradients of temperature, is but 2.6×10^{20} calories. We are left with 0.8×10^{20} calories as a measure of the radium present. On this allowance our theories, in whatever form, must be shaped. Nor does it appear as if relief from this restriction can be obtained in any other way than by denying to the interior parts of the earth the requisite high thermal conductivity. Taking refuge in this, we are however at once confronted with the possibility of internal stores of radium of which we know nothing, save that they can not, probably, be very great in amount. In short, I believe it will be admitted on full examination of this question that, while we very probably are isolated thermally from a considerable part of the earth's interior, the decay of the uranium must introduce a large subtractive correction upon our estimates of the limiting amounts of radium which might be present in the earth.

But, finally, is there in all these difficulties sufficient to lead us to reject the view that the present loss of earth-heat may be nearly or quite supplied by radium, and the future cooling of the earth controlled mainly by decay of the uranium? I do not think there are any good grounds for rejecting this view. Observe, it is the condition towards which every planetary body and every solar body containing stores of uranium must tend; and apparently must attain when the rate of loss of initial stores of heat, diminishing as the body grows colder, finally arrives at equilibrium with the radio-thermal supplies. This final state appears inevitable in every case unless the radio-active materials are so subordinate that they entirely perish before the original store of heat is exhausted.

Now, judging from the surface richness in radium of the earth and the present loss of terrestrial heat, it does not seem reasonable to assign a subordinate influence to radio-thermal actions; and it appears not improbable that the earth has attained, or nearly attained, this final stage of cooling.

How, then, may we suppose the existing thermal state maintained? A uniformly radio-active surface layer possessing a basal temperature in accordance with the requirements of geology is, I believe, not realizable on any probable estimate of the allowable radium, or on any concentration of it which my own experiments on igneous rocks would justify.

But we may take refuge in a less definite statement, and assume a distribution by means of which the existing thermal state of the crust may be maintained. A specially rich surface layer we must recognize, but this need be no more than a very few miles deep; after which the balance of the

radium may be supposed distributed to any depth with which we are thermally connected. Below that our knowledge is indefinite. The heat outflow at the surface is in part from the surface radium, in part due to the cooling arising from the diminishing amount of uranium, in part from the deep-seated radium. In this manner the isogeotherms are kept in their places, and a state is maintained which is in equilibrium with the thermal factors involved, but which can not be considered steady, using the word in a strictly accurate sense, in view of the decay of the uranium.

While the existing thermal state may, I think, thus be maintained by radio-active heating and radio-active decay, we find ourselves in considerable difficulties if we extend this view into the past and assume that the same could be said of any previous stage of the earth's history. If the heat emitted by the earth, when the surface was at melting temperature, was in a state of equilibrium with the radio-active supplies, then, at that date, there must have been many thousands of times the present amount of uranium on the earth, and the period of the *consistentior status* must be put back by thousands of millions of years. Apart from hopeless contradiction with every geological indication as to the age of the earth, difficulties in solar physics arise. For the sun must be supposed of equal duration, and we are required to assume impossible amounts of uranium to maintain his heat all that great lapse of time; and again this uranium would perish at just the same rate as that upon the earth, so that at the present time the solar mass must be, for by far the greater part, composed of inert materials of high atomic weight: the products of the transformations of the uranium family. The difficulty is best appreciated when we consider that even to maintain his present rate of heat-loss by radium supplies, some 60 per cent. of his mass must be composed of uranium. But there are other troubles to face if we adopt this view. The earth, or rather those parts of it which are sufficiently near the surface to lose heat at the requisite rate, would have cooled but one per cent. in 10^8 years. Shrinkage of the outer parts and crustal thickness will be proportionately small, and we must put back our epochs of mountain building to suit so slow a rate of cooling and skrinkage and refer the earlier events of the kind into a past of inconceivable remoteness. Otherwise we must abandon the only tenable theory of mountain formation with which we are acquainted. On such a time-scale the ocean would be supersaturated under the influence of the prolonged denudation like the waters of certain salt lakes, and the sediments would have accumulated a hundredfold in thickness.

Nor do the facts as we know them require from us such sacrifices. We are not asked to raise these difficulties on suppositious quantities of uranium for the existence of which there is no evidence. Radium has occasioned no questioning of the older view that the cooling of the earth from a *consistentior status* has been mainly controlled by radiation. But, on the contrary, this new revelation of science has come to smooth over what difficulties attended the reconciliation of physical and geological evidence on the Kelvin hypothesis. It shows us how the advent of the present thermal state might be delayed and geological time lengthened, so that Kelvin's forty or fifty million years might be reconciled with the hundred million years which some of us hold to be the reading of the records of denudation.

On this more pacific view of the mission of radium to geology, what has been the history of the earth? In the earlier days of the earth's cooling the radiation loss was

far in excess of the radio-thermal heating. From this state by a continual convergence, the rate of radiation loss diminishing while the radio-thermal output remained comparatively constant, the existing distribution of temperature near the surface has been attained when the radio-thermal supply may nearly or quite balance the loss by radiation. The question of the possibility of final and perfect equilibrium between the two seems to involve the interior conductivity and in this way to evade analysis.

It will be asked if the facts of mountain building and earth-shrinkage are rendered less reconcilable by this interference of uranium in the earth's physical history. I believe the answer will be in the negative. True, the greatest development of crustal wrinkling must have occurred in earlier times. This must be so, in some degree, on any hypothesis. The total shrinkage is, however, not the less because delayed by radio-thermal actions, and it is not hard to point to factors which will attend the more recent upraising of mountain chains tending to make them excel in magnitude those arising from the stresses in an earlier and thinner crust.

UNDERGROUND TEMPERATURE

It would be a matter of the highest interest if we could definitely connect the rise of temperature which is observed in deep borings and tunnels with the radio-activity of the rocks. We are confronted, however, by the difficulty that our deepest borings and tunnels are still too near the surface to enable us to pronounce with certainty on the influence of the radium met with in the rocks. This will be understood when it is remembered that a merely local increase of radio-activity must have but little effect upon the temperature unless the increase was of a very high order indeed. A clear understanding of this point shows us at once how improbable it is that volcanic temperatures can be brought within a very few miles of the surface by local radio-activity of the rocks. To account on such principles for an elevation of temperature of, say 1,200° at a depth of three or four miles from the surface, a richness in radium must be assumed far transcending anything yet met with in considerable rock masses; and as volcanic materials appear to show nothing of such exceptional richness in radium we can hardly suppose local radio-activity of the upper crust responsible for volcanic phenomena.

When we come to apply calculation to results on the radio-activity of the materials penetrated by tunnels and borings, we at once find that we require to know the extension downwards of the rocks we are dealing with before we can be sure that radium will account for the thermal phenomena observed. At any level between the surface and the base of a layer of radio-active materials—suppose the level considered is that of a tunnel—the temperature depends, so far as it is due to *local* radium, on the total depth of the rock-mass having the observed radio-activity. This is evident. It will be found that for ordinary values of the radium content it is requisite to suppose the rocks extending downwards some few kilometers in order to account for a few degrees in temperature at the level under observation. There is, of course, every probability of such a downward extension. Thus in the case of the Simplon massif the downward continuance of the gneissic rocks to some few kilometers evokes no difficulties. The same may be said of the granite of the Finsteraarhorn massif and the gneisses of the St. Gothard massif, materials both of which are penetrated by the St. Gothard tunnel, and which appear to possess a considerable difference in radio-activity. In dealing with this subject, comparison of the results ob-

tained at one locality with those obtained at another is the safest procedure. We must accordingly wait for an increased number of results before much can be inferred. I will now lay the cases of the two great tunnels as briefly as possible before you.

And first as to the temperature effects observed in the two cases.

The Simplon tunnel for a length of some seven or eight kilometers lies at a mean distance of about 1,700 meters from the surface. At the northerly end of this stretch the rock temperature attains 55°, and at the southern extremity has fallen to about 35°. The temperature of 55° is the highest encountered. The maximum predicted by Stapff, basing his estimates on his experience of the St. Gothard tunnel, was 47°. Other authorities in every case predicted considerably lower temperatures. Stockalper, who also had experience of the St. Gothard, predicted 36° at a depth of 2,050 meters from the surface, and Heim 38° to 39°.[13]

When the unexpectedly high temperatures were met with, various reasons were assigned. Mr. Fox has suggested volcanic heat. Others point to the arrangement of the schistosity and the dryness of the rocks, where the highest temperatures were read. The latter is evidently to be regarded more as explanation of the lower temperatures at the south end of the tunnel, where the water circulation was considerable, than of the high temperatures of the northern end. The schistosity may have some influence in bringing the isogeotherms nearer to the surface; however, not only are the rocks intensely compact in every direction, but what schistosity there is by no means inclines in the best directions for retention of heat. From the sections the schistosity appears generally to point upwards at a steep angle with the tunnel axis.[14]

Where there is such variability in the temperatures, irrespective of the depth of overlying rock, there is difficulty in assigning any significant mean gradient. The highest readings are obviously those least affected by the remarkable water-circulation of the Italian side. The higher temperatures afford such gradients as would be met in borings made on the level —about 31 meters per degree.

The temperatures read in the St. Gothard rocks were of a most remarkable character. For the central parts of the tunnel the gradients come out as 46.6 meters per degree. Stapff, who made these observations and conducted the geological investigations, took particular pains to ascertain the true surface temperatures of the rock above the tunnel; and from these ascertained temperatures, the temperatures in the tunnel rock and the overlying height of mountain, he calculated the gradients.

But this low gradient is by no means the mean gradient. At the north end, where the tunnel passes through the granite of the Finsteraarhorn massif, there is a rise in the temperature of the rock sufficient to steepen the gradient to 20.9 meters per degree. Stapff regarded this local rise of temperature as unaccountable save on the view that the granite retained part of the original heat. This matter I will presently return to.

Now, it is a fact that the radium-content of the Simplon rocks, after some allowance for what I have referred to as sporadic radium, stands higher than is afforded by the rocks in the central section of the St. Gothard, where the gradient is low. For the Simplon the general mean is (on my experiments) 7.1 billionths of a gram per gram. This mean is well distributed as follows:

[13] See the account given by Schardt, *Verhandl. Schweizerischen Naturf. Gesellsch.*, 1904, 87, "Jahresversammlung," pp. 204 ff.

[14] Schardt, *loc. cit.*

Jurassic and Triassic altered sediments	6.4
Crystalline schists, partly Jurassic and Tri-assic, partly Archean	7.3
Monte Leone gneiss and primitive gneiss	6.3
Schistose gneiss (a fold from beneath)	6.5
Antigorio gneiss	6.8

The divisional arrangement is Professor Schardt's. Forty-nine typical rocks are used in obtaining these results, and the experiments have been in many cases repeated on duplicate specimens. Including some very exceptional results, the mean would rise to 9.1×10^{-12} grams per gram.

Of the St. Gothard rocks I have examined fifty-one specimens selected to be, as far as attainable, representative.[15]

Of these, twenty-one are from the central region, and their mean radium content is just 3.3. The portion of the tunnel from which these rocks come is closely coincident with Stapff's thermal subdivision of regions of low temperature.[16] This portion of the mountain offers the most definite conditions for comparison with the Simplon results. The region south of this is affected by water circulation; the regions to the north are affected by the high temperature of the granite.

We see, then, that the most definite data at our disposal in comparing the conditions as regards temperature and radio-thermal actions in the two tunnels appear to show that the steeper gradient is associated with the greater radium-content.

It is possible to arrive at an estimate of the downward extension of the two rock masses (assumed to maintain to the same depth their observed radio-activity), which would account for the difference in gradient. In making this estimate, we do not assume that the entire heat-flow indicated by the gradients is due to radium, but that the difference in radium-content is responsible for the difference of heat-flow. If some of the heat is conducted from an interior source (of whatever origin), we assume that this is alike in both cases. We also assume the conductivities alike.

Calculating on this basis, the depth required to establish on the radium measurements the observed difference in gradients of the Central St. Gothard and of the Simplon, we find the depth to be about 7 kilometers on the low mean of the Simplon rocks, and 5 kilometers on the high mean. There is, as I have already said, nothing improbable in such a downward extension of primitive rocks having the radio-activities observed; but as a different distribution of radium may, of course, obtain below our point of observation, the result can only claim to be suggestive.

Turning specially to the St. Gothard, we find that a temperature problem of much interest arises from the facts recorded. The north end of the tunnel for a distance of 2 kilometers traverses the granite of the Finsteraarhorn massif. It then enters the infolded syncline of the Usernmulde and traverses altered sediments of Trias-Jura age for a distance of about 2 kilometers. After this it enters the crushed and metamorphosed rocks of the St. Gothard massif, and remains in these rocks for $7\frac{1}{2}$ kilometers. The last section is run through the Tessinmulde for 3 kilometers. These rocks are highly altered Mesozoic sediments.

I have already quoted Stapff's observations as to the variations of gradient in the northern, central and southern parts of the tunnel. He writes:

> They (the isotherms) show irregularities on the south side, which clearly depend on cold springs, they bend down rapidly, and then run smoothly

[15] I would like to express here my acknowledgments to the trustees of the British Museum for granting me permission to use chips of the rocks in their possession; and especially to Mr. Prior for his valuable assistance in selecting the specimens.

[16] *Trans. North of England Mining and Mech. Engineers*, XXXIII., p. 25.

inclined beneath the water-filled section of the mountain. Other local irregularities can be explained by the decomposition of the rock; but there is no obvious explanation of the rapid increase in the granite rocks at the northern end of the tunnel (2,000 meters), and it is probably to be attributed to the influence of different thermal qualities of the rock on the coefficient of increase. For the rest these 2,000 meters of granite belong to the massif of the Finsteraarhorn, and, geologically speaking, they do not share in the composition of the St. Gothard. Perhaps these two massifs belong to different geological periods (as supposed for geological reasons long ago). What wonder, then, if one of them be cooler than the other.[17]

Commenting on the explanation here offered by Stapff, Prestwich[18] states his preference for the view that the excess of temperature in the granite is due to mechanical actions to which the granite was exposed during the upheaval of this region of the Alps.

The accompanying diagram shows the distribution of temperature as given by Stapff, and the distribution of radium as found from typical specimens of the rocks. There is a correspondence between the two which is obvious, and when it is remembered that the increase in radio-activity shown at the south end would have been, according to Stapff, masked by water circulation, the correspondence becomes the more striking. The small radium values in the central parts of the tunnel are remarkable. The rocks of the Central St. Gothard massif are apparently exceptionally poor in radium.

At the north end the excess of radium is almost confined to the granite, the rock to which Stapff ascribed the exceptional temperatures. The radium of the Usernmulde is probably not very important, seeing that these sediments can not extend far downwards. The principal local source of heat appears located more especially beneath the synclinal fold, for Stapff's table (*loc. cit.*, p. 31) of the gradients beneath the plain of Andermatt shows a rising gradient to a point about 2,500 meters from the north entrance of the tunnel. It is observable that the radio-activity of the granite increases as it approaches the Usernmulde and attains its maximum (14.1) where it dips beneath the syncline.

The means of radium-content in the several geological sections into which the course of the tunnel is divisible are as follows:

Granite of Finsteraarhorn	7.7
Usernmulde	4.9
St. Gothard massif	3.9
Tessinmulde	3.4

The central section, however, if considered without reference to geological demarcations, would, as already observed, come out as barely 3.3. And this is the value of the radio-activity most nearly applicable to Stapff's thermal subdivision of the region of low temperature.

If we accept the higher readings obtained in the granite as indicative of the radio-active state of this rock beneath the Usernmulde, a satisfactory explanation of the difference of heat-flow from the central and northern parts of the tunnel is obtained. Using the difference of gradient as basis of calculation, as before, we find that a downward extension of about six thousand meters would, if the outflow took place in an approximately vertical direction, account for the facts observed by Stapff. This depth is in agreement with the result as to the downward extension of the St. Gothard rocks as derived from the comparison with the Simplon rocks.

We are by no means in a position to found dogmatic conclusions on such results; they can only be regarded as encouragement to pursue the matter further. The coincidence must be remarkable which thus similarly localizes radium and tem-

[17] *Loc. cit.*, p. 30.

[18] *Proc. R. S.*, XLI., p. 44.

perature in roughly proportional amounts, and permits us, without undue assumptions, to explain such remarkable differences of gradient. There is much work to be done in this direction, for well-known cases exist where exceptional gradients in deep borings have been encountered—exceptional both as regards excess and deficiency.

JOHN JOLY

(To be continued)

ABSTRACTS FROM THE ANNUAL REPORT OF THE PRESIDENT OF CORNELL UNIVERSITY

THE number of students enrolled in the university for the year ending September, 1908, was 4,465, of whom 3,734 were regularly enrolled students during the academic year from September to June, and the rest attendants at the summer session and the winter school in agriculture. This is an increase of 240 over the enrollment for the preceding year and an increase of more than 1,000 over the enrollment of four years ago, when the figures were 3,423.

A little more than half (2,025) of these 3,734 regular students came from New York State. From Pennsylvania came 322; New Jersey, 190; Ohio, 155; Illinois, 108, and Massachusetts, 101, while 690 came from forty-five other states and territories of the United States (including Porto Rico, Hawaii and the Philippine Islands), and 143 from twenty-eight different foreign countries (including China, 28; Cuba, 14; Argentine Republic, 14; Canada, 12; India, 11; Japan, 11; Mexico, 7; Brazil, 7; Peru, 6; England, 4; Australia, 3; Switzerland, 3, etc.).

The total number of students who have been enrolled in the university since it opened in 1868 is approximately 26,000 and the number of degrees conferred during these forty years is 10,475, more than three fourths of which have been conferred by President Schurman in the last sixteen years. The number of degrees granted in June, 1908, was 715, of which 649 were first degrees and 66 advanced degrees.

The number of members of the instructing staff is given as 548, and, excluding the members of the staff of the Medical College in New York City, the faculty at Ithaca is found to be made up as follows: 75 professors, 64 assistant professors, 6 lecturers, 122 instructors and 144 assistants. Twenty years ago there were 33 professors, 4 associate professors, 13 assistant professors, 41 instructors and 4 assistants.

President Schurman dwells on the necessity of higher professorial salaries for the purpose of maintaining the dignity, importance and attractiveness of the teaching profession in America. If intellect is to be well-trained in America there must be tangible evidence that the public set a fair value on highly educated men. Otherwise the best brains of the country will be lost to the teaching profession. As Burke has well said, "The degree of estimation in which any profession is held becomes the standard of the estimation in which the professors hold themselves." Hence it is scarcely an exaggeration to assert that the provision in Colonel Vilas's magnificent bequest to the University of Wisconsin for the establishment of certain professorships with salary of not less than $8,000 each will, if it becomes at once effective, mark an epoch in the development of a proper standard for the estimation of professors in the United States.

The problem of securing men of the highest character, ability and training to fill professorial vacancies is at best a difficult one. Cornell has never limited herself to the graduates of the university, to the state in which it is located, or even to America. Two years ago a gentleman in

France was appointed to a professorship; this year Leeds University, England, and Edinburgh University, Scotland, have furnished two professors.

One of the most important pieces of educational legislation, as President Schurman points out, was the establishment by the College of Arts and Sciences of an administrative board with direct supervision over the work of freshmen and sophomores in that college, and President Schurman states the underlying motive for this action in the following words:

> Among the best of our colleges and universities the great break in the course of a collegiate or liberal education comes at the end of the second year, both as regards the curriculum and the methods of instruction. This differentiation of the work, methods of instruction and educational aims of the first two years of the course in the college of arts and sciences in contrast with those of the later years of that course calls for a corresponding differentiation in the staff of instruction, which could not fail to insure greater thoroughness of instruction, greater simplicity and effectiveness of administration and closer personal and social intercourse between teachers and students.

It has been recognized at Cornell University that a scheme of education which permits students to elect their own studies, whatever its advantages, is at any rate attended with great risks, especially for the younger and inexperienced undergraduates; and for some time past a considerable portion of the work of freshmen and sophomores has been prescribed. But the care and supervision of these underclassmen has hitherto remained in the hands of the entire faculty of arts and sciences, a very large body, many of whom give no instruction whatever to freshmen and sophomores in arts. Now, however, these underclassmen will be under the direct charge of a distinct administrative board, composed of 17 members (of whom 14 are of professorial rank) selected from the teachers of freshmen and sophomore courses and this board is given full power to supervise their work and to provide means for making it effective.

In effect this board will be a separate faculty, which will have special charge of freshmen and sophomores, thus giving these underclassmen all the advantages of the small college faculty.

One of the most important problems which press for settlement upon the administrative board for freshmen and sophomores is the proper method of instructing underclassmen, and President Schurman brings forward the question in the following terms: The colleges and universities have in the past given less attention to improving the methods of teaching than the schools; and universities certainly have made the mistake of applying to freshmen the methods suitable to the graduate school or to the popular rostrum. But the freshman should not be treated either as an investigator or as a passive listener. Recitation, question and answer, and constant drill are the methods of instruction proper to the freshman class room. The object is assimilation by the ignorant pupil of knowledge with mental reaction upon it.

If the modern undergraduate is unresponsive in the class room, that is a natural result of the exclusive use of the lecture system. As one of the professors puts it in his report: "Intellectual overfeeding without intellectual exercise is bound to bring about mental torpor."

President Schurman also discusses fully the functions of graduate study. In the graduate department as in the university as a whole there is constant danger that the national tendency to worship mere magnitude may distort the vision of the faculty and especially of the trustees and friends of the university. It is important, therefore, to keep clearly in view the essential objects of a graduate school. These are

the enlargement of existing knowledge and the training of young men and women of superior ability and education in methods of independent investigation so that they too may, in time, make some contribution to the stock of human knowledge. A love of knowledge, an ardent desire to wrest something from the unknown, a conviction that science and scholarship are along with virtue the chief good of human life, would seem to be the animating motives of a life of research. Given this subjective equipment in combination with superior powers of observation, reasoning and imagination, and productive scholarship and science are assured. But these gifts are not possessed by all professors, and still less by all graduate students. And it is a grave question whether graduates of mediocre ability—minds lacking in energy, ambition and imagination—should, after they have demonstrated their quality in a probationary year, be encouraged or even permitted to continue work intended to fit men to become scholars and investigators.

The recommendations contained in President Schurman's report of last year in regard to the requirement of arts work for admission to the professional schools, have been under careful consideration by the faculties of the various colleges of the university and by the trustees, but final action has been deferred. The faculties of engineering and architecture have drawn up five-year courses as alternatives to the present four-year courses, in which they include over 70 hours in arts and sciences and at least 30 hours in literary and historical subjects. The faculty of law favor the requirement of a year and in the near future of two years of arts work for admission to the course in law. All these proposals are now under consideration. The medical college, on the other hand, has so advanced its requirements that a bachelor's degree or its equivalent is required for admission to the course in medicine. Finally, courses suitable for students in preparation for the vocations of teaching, organized philanthropy, the civil service and business management were arranged by the faculty of arts and sciences for the benefit of juniors and seniors in that college, and these groups of studies will hereafter be included in the list of electives.

President Schurman next devotes considerable space to the work and needs of the New York State Veterinary College which is by law dedicated to both instruction and research. Dr. Veranus A. Moore, the distinguished pathologist of the university, who has for years held the position of professor of pathology and bacteriology in the veterinary college, has been appointed director of that college to succeed Dr. Law, who retires on a pension provided by the Carnegie Foundation for the Advancement of Teaching. The minimum requirements which Dr. Moore sets down for next year are an increase of the annual legislative appropriation for maintenance from $30,000 to $40,000; a new annual appropriation to begin with $10,000 for research, experimental investigations and extension work; and a special appropriation of $125,000 for buildings and equipment for the clinical work of the college.

The total expense of adequately maintaining this college together with the interest on the first cost of the buildings when completed would equal but a fraction of one per cent. of the loss to our state by the death of animals from diseases that are largely preventable.

The great event of the year for the New York State College of Agriculture was the purchase by the university of additional farm lands which in combination with present holdings now gives the college of agriculture 579 acres for farming purposes, in addition to the 100 acres provided for the veterinary college for an experimental

station. Now that the university has greatly enlarged its farm, it will be possible, if state funds are available, to add to the live stock of the college, which is needed as material both for demonstration to students and research by professors. New York state produces about one ninth of the hay and forage of the United States, and the animal industries of the state are of enormous value. This is a field, therefore, to which the instruction and investigation of the college should be peculiarly directed, and the state appropriation of $25,000 for barns has solved the problem of housing facilities as the purchase by the university of land has solved the problems of pastures and fodder.

New courses have been added to the curriculum in the college of civil engineering, notably in the field of sanitary engineering, but President Schurman points out that there is still necessity for improvement in the field of hydraulics, and he adds that strong as the department of hydraulics now is it is greatly in need of development to meet the demands of the age and the prospects of the future. Water is destined from now on to play a great part in the economic development of the United States, for apart from its uses for domestic and sanitary purposes, it is hereafter to be used on a vast scale for power and for irrigation as well as for navigation. The maximum benefit to be got will be sought in the east from navigation and power and in the west from irrigation and power. For the new work to come in these vast fields there will be needed a type of engineer highly specialized in hydraulics.

In addition to the farm lands purchased for the State College of Agriculture and the State Veterinary College, President Schurman announces the acquisition of nearly 50 acres of land as an extension of the campus proper on the southeast, thus making the entire area now included in the campus 350 acres, the distance north and south being about five eighths of a mile, and the distance east and west about a mile. The university campus and farms now aggregate nearly 1,100 acres.

Coming to the finances of the university, President Schurman reports that excluding the medical college in New York City, which is maintained by separate funds, the productive funds of the university amounted on August 1, 1908, to $8,628,370.31 as compared with $8,550,916.84 on August 1, 1907, while the inventoried value of the university grounds and buildings at the present time is given as $4,263,405.07. The most marked changes in the investments during the year were an increase in steam railroad bonds from $1,019,500 to $1,414,100 and a decrease in real estate mortgages from $1,515,538.48 to $1,324,217.66. The income statement shows a total income from all sources of $1,356,498.59. The income of the university at Ithaca, excluding the state colleges, ran short of the expense budget by $12,242, as a result of the purchase of campus lands.

President Schurman closes his report with a brief but cogent statement of the most pressing needs of the university, first among which he places endowments for the augmentation of the present low salaries of professors and instructors, who, as the president points out, are the vital and energizing soul of any university. Next comes the need of a system of residential halls and commons for the young men of the university, thousands of whom are now obliged to seek accommodations in private boarding and lodging houses throughout the city. After these in order of importance, though equally urgent for the conduct of the work of the university, are mentioned the need of a general assembly hall capable of accommodating the entire student body, a new and greatly enlarged armory, a new laboratory for veterinary

clinics, a new testing and experimenting laboratory in civil engineering, new machine shops in mechanical engineering, and an entirely new establishment for the department of chemistry, where the great increase in the number of students taking the work has created serious embarrassment even necessitating the exclusion from the already overcrowded laboratory of undergraduates in whose courses chemistry is a prescribed or elective subject. A new chemical laboratory entirely adequate for the purpose would, as President Schurman estimates, cost from $300,000 to $400,000.

THE DELOS ARNOLD COLLECTIONS OF NATURAL HISTORY SPECIMENS

HON. DELOS ARNOLD, of Pasadena, has presented to the department of geology of Stanford University his great collection of fossils, shells, corals, minerals, ethnologic materials, etc. This collection is a gift to the university on the condition that it be kept intact, and that it be properly cared for, labeled and exhibited. It represents the work of a lifetime by an enthusiastic student and collector, and is one of the finest private collections of fossils in the country. It is especially valuable on account of the large amount of recent and Tertiary material collected on the west coast of North America. For the use of students of the geology of California and the west coast generally, it is without an equal.

The collection was begun by Mr. Arnold in 1860 when he lived in the state of Iowa, and besides the constant work done upon it by him, it has received many acquisitions up to 1908, and it is stipulated by the donor that still further additions may be made to it in the future. Most of the minerals were collected in Colorado in the seventies and in Arizona in the eighties.

The collection of recent marine shells so necessary in the study of Tertiary geology is one of the finest in this part of the country, and it embraces a large amount of material collected on the Atlantic coast from Maine to the West Indies. It includes most of the common forms both of shells and corals and a large number of the rarer ones collected by Mr. Arnold at Jacksonville, Key West, St. Augustine and New Orleans. Of the west coast materials, it embraces collections made by Mr. Arnold and his son Dr. Ralph Arnold almost continually all the way from Puget Sound to Panama, and includes both the littoral species and the deeper water forms obtained by dredging. There are also a good many shells obtained by exchange and purchase from Europe and other parts of the world, and especially from the Mediterranean Sea, from the coasts of France, and from the Hawaiian Islands. A representative collection of fresh-water shells from various parts of the United States is also included in the materials.

The fossils, however, form the most important part of the collection. These embrace Paleozoic, Mesozoic, Tertiary and Pleistocene forms. The paleozoic materials include one of the best collections ever made from the famous crinoid-bearing Kinderhook beds (Carboniferous) at Le Grand, Iowa. Many of these fine specimens are types, and are figured in Wachsmuth and Springer's monograph on the crinoids. Of especial interest in connection with the collection of fossil crinoids is a beautiful specimen of a living crinoid from the China Sea.

The Mesozoic materials of the collection come from different parts of North America, notably from California, and the Dakotas, and from Europe.

The collection of Tertiary and Pleistocene fossils is among the best of the kind in existence, and, in many respects, it is unique. It includes a number of types and a large number of specimens that have been figured in publications upon the Tertiary and Pleistocene of the Pacific coast, notably in the papers published by Dr. Ralph Arnold, the distinguished son of the donor. Getting together this particular part of the collection has occupied Mr. Arnold's time for twenty-two years. At San Pedro, one of the richest and most important localities where collecting

has been done, the collecting ground has been encroached upon by the sea and carried away for ballast until the fossil-bearing beds have now been nearly destroyed, and similar collections thus made impossible. There are besides full collections from all the known Pleistocene localities from Puget Sound to Scammon's Lagoon in Lower California. The collections from Santa Barbara and San Diego are large and especially fine. There is also much valuable material obtained by exchange from Dr. M. Cossman and Jean Miguel, of France, and from Dr. Koto, of Japan. Representative Tertiary and Pleistocene materials of the eastern United States have been received from Professor Gilbert D. Harris, of Cornell University, from T. H. Aldrich, of Birmingham, Alabama, from the Chicago Academy of Sciences, and from many other persons and institutions. It is estimated that the collection contains 30,000 species and considerably more than 30,000 duplicates.

The new exhibition cases in the geological department will be used for the display of the collection. It will occupy part of the large museum room on the ground floor adjoining the geological lecture room. It will be kept together, and will be known as the "Delos Arnold Collection."

Hon. Delos Arnold, of Pasadena, who made the collections of fossils, shells, minerals, etc., known as the "Delos Arnold Collection" lately presented by him to the department of geology in Stanford University, was born July 21, 1830, in Chenango County, N. Y. He was educated in the common schools of that state, and at Fredonia Academy in Chautauqua County, N. Y. He studied law at the Albany Law School, from which he graduated in 1853. In that same year he moved to Marshalltown, Iowa, and lived there until 1886. For several years he was district attorney and treasurer of Marshall County. He was appointed United States Assessor of Internal Revenue for the Sixth Iowa District by President Lincoln, and served four years. For twelve years he was a member of the Iowa legislature, having been four years member of the general assembly, and eight years member of the senate. He was also special state auditor to examine the accounts in connection with the state capitol of Iowa. In 1886 Mr. Arnold moved to Pasadena, California, and has lived there ever since. For ten years he was a member of the school board of the city of Pasadena.

THE DEPARTMENT OF MICROSCOPY OF THE BROOKLYN INSTITUTE OF ARTS AND SCIENCES

THE regular meetings of the department of which Mr. John J. Schoonhoven, M.A., is president, and Miss Agnes Vinton Luther, secretary, will be held during the season on the second and fourth Tuesday evenings of each month. The proceedings at the meetings are as follows:

October 13—Conference on "The City's Water Supply," to be conducted by Mr. Daniel D. Jackson, S.B., director of the Mount Prospect Laboratory of the Division of Water Supply. The subject of the conference will be illustrated by lantern photographs.

October 27—Lecture by William H. Park, M.D., of the Research Laboratory of the Department of Health, New York City, on "The Recent Research Work of the Department of Health."

November 10—Conference on "Textile Fibers," to be conducted by Miss Agnes Vinton Luther, secretary of the department.

November 24—Lecture by Professor William Campbell, Ph.D., of Columbia University, on "The Microscopical Structure of Metals and Alloys, Native and Artificial."

December 8—Conference on "The Use of the Microscope in the Detection of Poisons in Chemical Analysis," to be conducted by Mr. Herbert B. Baldwin, chemist for the Board of Health, Newark.

December 22—Lecture by Professor Herbert W. Conn., Ph.D., of Wesleyan University, on "Rabies."

January 12—Conference on "Photography Applied to Microscopy," to be conducted by Messrs. George E. Ashby and J. P. Wintringham, members of the executive committee of the department.

January 26—Lecture on "The History and Recent Improvements in the Projection Microscope," with demonstrations, by Professor Simon Gage, Ph.D., of Cornell University.

February 9—Conference on "The Use of the

Microscope in the Manufacture of Paints," to be conducted by Mr. Maximillian Toch, president of the New York Chemical Society.

February 23—Lecture by Mr. John J. Schoonhoven, M.A., president of the department, on "Some Interesting Vegetable Parasites affecting Man and the Lower Animals."

March 9—Conference on "The Microscopical Examination of Milk." Harris Moak, M.D., professor of bacteriology, Long Island College Hospital, has been invited to conduct this conference.

The twenty-second annual exhibition of microscopic preparations and apparatus will be held in the new suite of rooms in the Academy of Music on Saturday afternoon and evening, March 13, 1909, by members of the department. Ninety-seven microscopes were in use during the evening at the last annual exhibition. There will be a private view of the exhibition for members and invited guests on Friday evening, March 12.

March 23—Conference on "The Microscopical Study of Insects," to be conducted by Mr. Carl Schaeffer, associate curator of entomology of the institute.

April 13—Conference on "The Use of the Microscope in Domestic Science." Miss Edith M. Greer, of the department of domestic science, has been invited to conduct this conference.

April 27—Conference to be conducted by Wallace Goold Levison, B.Sc., vice-president of the department of geology, on some subject in "Microscopical Mineralogy."

May 11—Conference to be conducted by Mrs. Helen W. Joy, member of the executive committee of the department, on "Vegetable Histology."

May 25—Conference on "Fresh-water Life," to be conducted by Professor Richard W. Sharpe, M.S., of the DeWitt Clinton High School, vice-president of the department of zoology.

THE ASSOCIATION OF COLLEGES IN NEW ENGLAND

THE fifty-second annual meeting of the Association of Colleges in New England was held at Boston University on October 29 and 30. The twenty-one subjects suggested by the several colleges may be quoted as indicating current academic problems:

1. The future of colleges and universities which collect tuition fees. (Suggested by Harvard.)

2. What arrangements are possible or desirable in order to stimulate intellectual emulation among college students? (Suggested by Yale.)

3. Is it desirable and feasible to bring about an intercollegiate understanding tending to prevent unnecessary duplication of courses where instruction is expensive and students few in number? (Suggested by Yale.)

4. The desirability of exchanges for one year between professors in American colleges. (Suggested by Brown.)

5. When should education begin to be distinctively vocational? (Suggested by Vermont.)

6. The faculty supervision of student organizations. (Suggested by Vermont.)

7. The present trend away from the ideals of the liberal education. (Suggested by Williams.)

8. The control of attendance on college exercises: how much absence should be permitted? (Suggested by Williams.)

9. Scholarships, scholarship, and bribery. (Suggested by Middlebury.)

10. Should colleges, not having graduate schools, give the degree of Master of Arts, in course? (Suggested by Amherst.)

11. Shall the scale of units for entrance proposed by the Carnegie Foundation be doubled so as to avoid half-units? (Suggested by Amherst.)

12. The economic waste of the present method of conducting entrance examinations by the separate colleges. Will the colleges in New England unite upon the examinations of the College Entrance Board or some similar system of uniform examinations? (Suggested by Trinity.)

13. Allowed absences. (Suggested by Trinity.)

14. Is there any general usage at present in regard to the Day of Prayer for Colleges? (Suggested by Wesleyan.)

15. What is the proper attitude of college faculties towards hazing—prohibition or regulation? (Suggested by Wesleyan.)

16. Is the growing interest in vocational training endangering the ideals of liberal education? (Suggested by Boston.)

17. The universitizing of the college: its cause and cure. (Suggested by Clark.)

18. Can the evils of athletics be mitigated by an academic course leading to degrees in its historical, scientific, academic, social and other aspects? (Suggested by Clark.)

19. College requirements in English. (Suggested by Clark.)

20. Are the relations of the New England colleges to the high school on a sound basis? (Suggested by Clark.)

21. Reform in the college-entrance requirements

in Latin. (Presented by the Classical Association of New England.)

The colleges were represented as follows during the meeting:

Harvard University—President Charles W. Eliot; Jerome D. Greene, secretary.

Yale University—President Arthur T. Hadley; Edward P. Morris, professor of Latin.

Brown University—President William H. P. Faunce; Walter G. Everett, professor of philosophy and natural theology.

Dartmouth College—President Wm. J. Tucker; Frank H. Dickson, professor of economics.

University of Vermont—President Matthew H. Buckham; Max W. Andrews, professor of English.

Williams College—President Harry Augustus Garfield, Dean Frederick C. Ferry.

Bowdoin College—President William DeWitt Hyde; Frederick Willis Brown, professor of modern languages.

Middlebury College—President John M. Thomas; Myron R. Sanford, professor of Latin.

Amherst College—President George Harris; James W. Crook, professor of economics.

Wesleyan University—Acting President William North Rice; Karl P. Harrington, professor of Latin.

Tufts College—President Frederick W. Hamilton; Philip M. Hayden, instructor in modern languages.

Boston University—President William E. Huntington; Lyman C. Newell, professor of chemistry.

Clark University—President G. Stanley Hall; Carroll D. Wright, president of Clark College.

WINTER MEETING OF THE AMERICAN CHEMICAL SOCIETY

The Winter Meeting of the American Chemical Society will be held in Baltimore, Md., December 29 to January 1 inclusive. The meeting will be in affiliation with the American Association for the Advancement of Science and the Biological Section will hold a joint session with the Society of Biological Chemists.

The following members have consented to preside over sections and to aid in the preparation of the program for the meeting.

Agricultural and Food Chemistry—H. J. Wheeler.
Biological Chemistry—J. J. Abel.
Inorganic Chemistry—C. H. Herty.
Organic Chemistry—S. F. Acree.
Pharmaceutical Chemistry—Edw. Kremers.
Chemical Education—H. P. Talbot.
Fertilizer Chemistry—F. B. Carpenter.
Physical Chemistry—G. N. Lewis.
The Division of Industrial Chemists and Chemical Engineers will also hold a meeting presided over by the chairman of the division, A. D. Little.

Members desiring to present papers are requested to send title and brief abstracts to one of these persons or to the secretary of the society with the exception of the Section of Chemical Education where a special program is being arranged. The final program will be sent only to those members signifying their intention of being present at the meeting, or who make special request for same. No title can be placed on the final program that reaches the secretary later than December 10.

Chas. L. Parsons,
Secretary

Durham, N. H.

SCIENTIFIC NOTES AND NEWS

The president and council of the Royal Society have awarded medals as follows: the Copley medal to Dr. Alfred Russel Wallace, in recognition of the great value of his numerous contributions to natural history, and of the part he took in working out the theory of the origin of species by natural selection; the Rumford medal to Professor H. A. Lorentz, for his investigations in optical and electrical science; a Royal medal to Professor John Milne, for his preeminent services in the modern development of seismological science; a Royal medal to Dr. Henry Head, for his researches on the relations between the visceral and somatic nerves and on the functions of the afferent nerves; the Davy medal to Professor W. A. Tilden, for his discoveries in chemistry, especially on the terpenes and on atomic heats; the Darwin medal to Professor August Weismann, for his eminent services in support of the doctrine of evolution by means of natural selection; the Hughes medal to Professor Eugene Goldstein, for his discoveries on the nature of electric discharge in rarefied gases.

COLONEL GEORGE H. TORNEY will succeed Brigadier General Robert M. O'Reilly as surgeon general of the army on January 14.

IT is unofficially stated that Mr. William Marconi is to be awarded the next Nobel prize in physics.

A LIFE-SIZED portrait of Dr. John Galbraith, professor of engineering at the University of Toronto, has been presented to the university on the occasion of the thirtieth anniversary of his appointment.

THE Institution of Civil Engineers, London, has made the following awards for the year 1907–8: Telford gold medals to W. B. Parsons and Dr. H. Lapworth; a Watt gold medal to Sir Whately Eliot; George Stephenson gold medals to Sir John W. Ottley, K.C.I.E., Dr. A. W. Brightmore, J. S. Wilson and W. Gore.

THE Bisset Hawkins gold medal of the Royal College of Physicians has been awarded to Sir Shirley Murphy, medical officer of health of the County of London, for his distinguished services in the cause of public health.

PROVOST CHARLES C. HARRISON will represent the University of Pennsylvania at the Darwin celebration at Cambridge University in June next.

DR. OSTWALD SCHMIEDEBERG, director of the Pharmacological Institute at Strasburg, has celebrated his seventieth birthday.

DR. LUDWIG MOND, F.R.S., has been decorated with the Grand Cordon of the Crown of Italy.

DR. CARL L. ALSBERG has resigned his position in the department of physiological chemistry of the Harvard Medical School, to take charge of the poisonous plant investigations in the Bureau of Plant Industries of the U. S. Department of Agriculture.

PROFESSOR DORSEY A. LYON, of the department of metallurgy in Stanford University, has resigned to become manager of an electrical smelting plant.

DR. H. HERGESELL, director of the Meteorological Bureau for Alsace-Loraine, has been transferred to the Department of the Interior, Berlin.

KING HAAKON has headed the public subscription for Captain Amundsen's polar expedition with a donation of $5,000.

DR. SIEBERS, of Giessen, is in charge of an expedition to Peru, supported by the Karl Ritter foundation of Leipzig.

PROFESSOR V. L. KELLOGG, of Stanford University, now in Italy, has been granted leave of absence for the remainder of the year.

KUO FENG-NING, of Shanghai, China, a delegate of the Chinese Fisheries Company to the recent International Fisheries Congress at Washington, and Kohang Yih, who is investigating tobacco growing in this country, are visiting our colleges of agriculture and experiment stations.

SIR HORACE PLUNKET, formerly of the agricultural department in Ireland, has left for the United States, on invitation, to confer with the Commission on Country Life, appointed by President Roosevelt.

DR. F. M. SMITH, head of the department of agriculture of the Transvaal, South Africa, is visiting this country to gather information in agricultural education in view of a contemplated college of agriculture at Prætoria.

THE Pathological Society of Philadelphia, at its meeting on October 22, elected the following officers: *President,* Dr. Joseph McFarland; *Vice-Presidents,* Drs. Edsall, Reisman, Kelly and Smith; *Secretary,* Dr. R. S. Lavenson; *Treasurer,* Dr. C. Y. White; *Recorder,* Dr. F. H. Klaer; *Curator,* E. H. Goodman.

DR. E. E. SLOSSON, of the New York *Independent,* is collecting material for a series of articles on the leading universities of the United States. He has spent the past two weeks at Stanford University and the University of California.

IN view of the development of flying machines and airships during the past few months, the American Society of Mechanical Engineers have arranged for an exhaustive paper on aeronautics by Major George O. Squier, of the Signal Corps, U.S.A., Washington, D. C., to be read at the annual meeting in New York, December 1–4. An evening lecture upon aeronautics will be given by

Lieutenant Frank P. Lahm, of the Signal Corps, illustrated with lantern views and moving pictures of the recent trials at Fort Myer.

A series of special lectures on general hygiene, provided for by the regents of the University of Wisconsin at their last meeting, is now being arranged by Dr. H. P. Ravenel, of the department of bacteriology. Among the speakers will be Professor William T. Sedgwick, of the Massachusetts Institute of Technology, who will speak on ventilation and water supply.

The faculty of Tulane University announces a course of extension lectures, which began October 28. The course includes a series of lectures by Professor George Dock, on "Ductless Glands," to be followed by lectures on special subjects, by Dr. Ch. Wardell Stiles, Public Health and Marine Hospital Service; F. Creighton Wellman, of the Department of Agriculture; Dr. William A. Evans, health commissioner of Chicago; Dr. W. H. Dalrymple, of the Louisiana State Department of Agriculture, and others.

Dr. Ch. Wardell Stiles, of the Public Health and Marine Hospital Service, gave two lectures with demonstrations at the University of Virginia on November 6 and 7. His subject was the biological, economical and medical aspects of the hook-worm disease in this country.

Professor W. M. Davis, of Harvard University, gave an illustrated lecture on the Colorado Cañon before the Natural History Section of the Versammlung der Deutschen Naturförscher und Aerzte in Cologne, on September 24, as well as at the meeting of the British Association earlier in the month.

A bronze tablet commemorative of the early geological work of the late Professor James Hall during the New York Survey of 1836–42 has been erected in Letchworth Park, the new state preserve on the Genesee River, by a few of the associates of Professor Hall's later years: Secretary Walcott, Professors Stevenson, Smock and Schuchert and Dr. Clarke.

Harvard University has received from the director and members of the Pasteur Institute of Paris a replica of the bronze bust of Pasteur by Paul Dubois. The bust will be erected at the Medical School.

The medical profession of Algiers has placed in the military hospital of Constantine, on the spot which served Laveran for a laboratory, and where he accomplished his memorable work, a medallion commemorating the discovery of the parasite of malaria in 1880. Another commemorative medallion has been placed in the hall of honor of the hospital by the military physicians.

William Keith Brooks, professor of zoology in the Johns Hopkins University since 1876, died on November 12, at the age of sixty years.

Otis Tufts Mason, head curator of the department of anthropology of the U. S. National Museum, and eminent for his contributions to anthropology, died in Washington on November 5, at the age of seventy years.

Professor William Edward Ayrton, professor of electrical engineering in the Central Technical College, London, died on November 8 at the age of sixty-one years.

There is a vacancy in the position of assistant (male) U. S. Naval Observatory, with pay at the rate of $1,000 per annum, and the Civil Service Commission will order an examination for eligibles for same in the near future. Those interested in such an examination, should inform the observatory in order that application blanks may be mailed to them.

An examination for admission to the grade of assistant surgeon in the Public Health and Marine-Hospital Service will be held on January 11, at Washington. Candidates must be between twenty-two and thirty years of age, and graduates of a reputable medical college. Assistant surgeons receive $1,600, passed assistant surgeons, $2,000, and surgeons, $2,500 a year. For further information application should be made to the Surgeon General, Public Health and Marine-Hospital Service, Washington, D. C.

SECRETARY WRIGHT has forwarded to the secretary of the treasury the detailed estimates for the war department for the next fiscal year. For the purchase of aerial machines, either dirigible balloons or aeroplanes, $500,000 is asked.

THE annual meeting of the American Anthropological Association will be held in Baltimore, December 28, 1908, to January 2, 1909, in affiliation with the American Folk-Lore Society and Section H of the American Association for the Advancement of Science. Titles (and abstracts) of papers should be sent immediately to Dr. George Grant MacCurdy, Yale University, New Haven, Conn., who is responsible for the combined program.

IN the Hall of Fossil Mammals of the American Museum of Natural History several important additions and changes have been made during the past few months. A specimen of the four-toed horse (*Orohippus osbornianus* Cope) from the Middle Eocene beds of the Bridger Basin, Wyoming, has been placed on exhibition. This was a small animal of about the same size as its ancestor in the Lower Eocene beds. It had four toes in the fore feet and three in the hind feet, but there are no vestiges of the fourth toe remaining. Last year's expedition to Egypt is brought to mind by an exhibit consisting of the skull and lower jaws of the Horned Arsinoithere. This gives one, too, some hint of the strange appearance of one of the animals inhabiting northeastern Africa in Upper Eocene time. The large skeleton of the great saber-tooth tiger, *Smilodon,* from the Pleistocene beds of South America, has been put into a case by itself, in which is also exhibited an oil painting by Charles R. Knight representing the animal as it is supposed to have appeared in life. There has been placed in the Amblypod Alcove at the west entrance to the hall a splendid composite skeleton of Uintatherium. This was a huge four-toed, elephantine, hoofed animal with large dagger-like tusks.

MR. H. M. TAYLOR, F.R.S., of Trinity College, Cambridge, has been instrumental in collecting about $2,500 for the publication of works of a scientific nature in embossed type for the use of the blind. The managers of the fund have agreed that the first three books in the publication of which they undertake to assist shall be "Sound and Music," by Mr. Sedley Taylor; "A Primer of Astronomy," by Sir Robert Ball, F.R.S.; and "An Introduction to Geology," by Dr. Marr, F.R.S.

ARRANGEMENTS have been made at Columbia University for a series of non-technical lectures on the various aspects of the science of meteorology, to be delivered on Tuesday afternoons at five o'clock, beginning January 12. These will include a general introductory lecture by President Woodward, of the Carnegie Institution of Washington (formerly professor of mechanics at Columbia, and the following lectures on specific topics: "The Geological Relation of Meteorology," by Professor A. P. Brigham, of Colgate University; "Climate in Some of its Relations to Man," by Professor R. DeC. Ward, of Harvard; "Astronomical Climate," by Professor William Libbey, of Princeton; "Storms and Weather Forecasting," by Willis L. Moore, chief of the United States Weather Bureau; "Circulation of the Atmospheres of the Sun and the Earth," by Professor F. H. Bigelow, of the Weather Bureau; "Exploration of the Atmosphere by Kites and Balloons," by Professor W. R. Blair, of the Weather Bureau; "Seismology," by Professor C. F. Marvin, of the Weather Bureau; "Atmospheric Phenomena and Physical Theory," by Professor J. H. Jeans, of Princeton University, and "Outstanding Problems in Meteorology," by Professor Cleveland Abbe, of the Weather Bureau.

THE *Medical Record* states that the first of the new buildings at Bellevue Hospital, New York City, has been opened. This has just been completed at a cost of something over a million dollars. The building is seven stories high, and contains two pavilions, known as A and B, of eight wards each, altogether accommodating about four hundred patients. The top floor will be devoted to wards for maternity cases, and the children's and medical wards will be housed on the lower floors. In the main building it will now be possible to

have four wards for the tuberculosis patients, who have hitherto been housed in small wooden buildings along the river front. These will be abandoned, as well as the building outside the hospital grounds which has been used for maternity cases.

The Journal of the American Medical Association states that Dr. John Gorrie was the first to invent a practical ice-making machine. It continues: The point in regard to Dr. Gorrie's invention which does him most honor is that it was made for the comfort and welfare of his fever patients. In 1845, when Dr. Gorrie was practising in Apalachicola, that town, though the most important Florida seaport, being the outlet for all the cotton grown in the Chattahoochee valley in Georgia and Alabama, was seriously hindered in its growth by the prevalence of various fevers in the summers. Dr. Gorrie found it almost impossible to treat fever patients successfully during the hot weather. He realized that cooling the patient's room would undoubtedly be of benefit, and he, therefore, set himself to devising various methods of cooling air and water. In 1850 he succeeded in producing small blocks of ice about the size of the ordinary building brick. A French cotton buyer, M. Rosan, residing in Apalachicola, saw the machine in operation and induced the inventor to give a public demonstration at the leading hotel. Ice made with the machine, which was placed on a table in the dining-room, was served to all those present at a banquet. M. Rosan later returned to Paris and is known to have been in intimate association with M. Carré, whose process of making ice was not perfected until 1855. There seems no doubt then that the Frenchman was spurred to renewed efforts, if not actually prompted to the idea of his invention, by the news of the successful experiment made by the American physician.

PRESIDENT ELIOT'S RESIGNATION

After a football mass meeting in the Harvard Union the students went in a body to President Eliot's house and he made to them a brief address which is reported in the *Transcript* as follows:

This is a great surprise, and I greatly appreciate your coming. Yesterday I was asked to talk upon the reasons for my resignation, but I refused. To-night I think I should like to say a few words to you on the subject.

I have heard a number of reasons suggested as the explanation of my resigning. Now I am not sick, I am not tired, and I am in good health so far as I am aware. My faculties and health are still good, I am glad to say. My resignation is meant to precede the time when they may cease to be so. When a man has reached the age of seventy-four it is time to look for rest and retirement. Dr. Arnold, of Rugby, used to say that a man was no longer fitted to be headmaster of a public school when he could not come up the steps two at a time. Now I can still do that.

I don't like to have my coming retirement spoken of with regret. It is touching to find that feeling, but I think it is something to be looked forward to with hope. We must all set to work to find some young, able, active man for the place. He can be found; we shall find him. We need a man who will take up this extremely laborious and extremely influential position with untiring energy and carry this university to a higher plane than it now occupies. It has been the foremost American university for 270 years.

The occupation which has been mine for a lifetime has been a most pleasant one, and I regret that it is about to terminate. Forty years of service has been given me in the pursuance of a profession that has no equal in the world. This university has grown into great proportions. It is now the task of all of us to find a man who can enlarge it still more and make it still greater. Good-night.

UNIVERSITY AND EDUCATIONAL NEWS

Dr. Richard C. MacLaurin, for the past year professor of mathematical physics in Columbia University and previously professor of mathematics in the University of New Zealand, has accepted the offer of the presidency of the Massachusetts Institute of Technology.

The appropriation by the New York City Board of Estimate and Apportionment of more than $586,000 for the maintenance of the City College next year, of which amount $404,000

will be devoted to instructional purposes, gives an increase of $50,000 over the total appropriations for the present year. Forty thousand dollars of the increase is in the allotment for instructional purposes.

COOPER MEDICAL COLLEGE, San Francisco, has been made the medical department of Stanford University.

THE Keokuk Medical College, of Keokuk, Iowa, has been merged with the College of Medicine of Drake University, at Des Moines.

THERE have lately been added a thousand acres to the reservation of the Forest Summer School of Yale University at Milford, Pa. Students of the Scientific School seeking advanced courses in forestry must take extra scientific courses in the senior year and pass two sessions at the Forest Summer School, to which seven new courses have been added.

THE new building for biology and geology at Amherst College has reached a point where it is nearly ready for its roof. It has a frontage of about 140 feet and is two stories high. The construction is of reinforced concrete.

THE new directory of the University of Wisconsin, now in press, shows 3,237 students in attendance, exclusive of the winter dairy and agriculture courses and the summer session. With these added the total attendance will exceed 4,500. The freshman class this year numbers 945, an increase of 106 over that of last year.

AT a meeting of the board of trustees of the University of Arkansas, on November 5, Dr. C. F. Adams was made acting dean and director of the College of Agriculture and Agricultural Experiment Station, succeeding W. G. Vincenheller, resigned.

DR. FREDERIC BRUSH, of Boston, has been appointed superintendent of the New York Post-graduate Medical School and Hospital.

DR. W. A. SYME has been promoted from an instructorship in chemistry to be assistant professor of chemistry in the North Carolina College of Agriculture and Mechanic Arts, and Mr. Hubert Hill, B.S., M.S. (University of North Carolina), has been appointed instructor in chemistry. Mr. J. K. Plummer, B.S. (North Carolina A. & M. College), has been appointed assistant chemist of the Experiment Station.

REGINALD E. HORE, instructor in petrography at the University of Michigan, has resigned, to take a position of lecturer on geology at the School of Mining, Kingston, Canada.

MR. ELLIS L. EDWARDS (Oklahoma, '05), lately a graduate student at the University of Nebraska, has been appointed tutor in geology at the University of Texas.

DR. T. R. ELLIOTT, late scholar of Trinity College, Cambridge, has been elected to a fellowship at Clare College. Dr. Elliott was placed in the first class of the Natural Sciences Tripos in 1900 and 1901.

THE following have been elected to fellowships at St. John's College, Cambridge: Mr. W. L. Balls, M.A., first class of the natural sciences tripos (botany); bracketed for the Walsingham medal. Mr. Balls is at present engaged in scientific investigations connected with cotton in Egypt. Mr. J. A. Crowther, B.A., first class of the natural sciences tripos (physics); Hutchinson research student at St. John's College; research student at Emmanuel College; Mackinnon student of the Royal Society. Mr. Crowther is at present residing in Cambridge and is engaged in physical research.

DR. F. W. LAMB has resigned his post as assistant lecturer in physiology at University College, Cardiff, on his appointment as senior demonstrator in physiology at Victoria University, Manchester, and the council have appointed Mr. R. R. M'Kenzie Wallace, of Cambridge University, to succeed him.

DISCUSSION AND CORRESPONDENCE

THE TRAINING OF INDUSTRIAL CHEMISTS

TO THE EDITOR OF SCIENCE: The address of Professor F. S. Kipping to the Chemical Section of the British Association, at the recent Dublin Meeting, and reported in abstract in the current issue of SCIENCE (October 30, 1908), contains some opinions which deserve the attention of all thoughtful teachers of industrial chemistry. The critical condition of

England, the realization of this situation, and the scholarship and standing of Professor Kipping, all vouch for the sincerity of the views expressed; and these considerations make it more surprising that this able student and teacher should, as reported, deliberately advise against the methods of teaching industrial chemistry which are now recognized as capable of giving practical results. The unfortunately conservative views expressed are still more interesting, because Professor Kipping explicitly states that "This section . . . does not attempt to distinguish pure from applied chemistry." This sentence should be noted; for it implicitly recognizes the common sense of the question, What is it good for; a question which should be the text and guide of all teaching and research.

The views of Professor Kipping are told in these words:

> On consulting the opinions of the manufacturers, it would seem that they attach great importance to what is called the "practical side"; they believe that, in addition to a knowledge of theoretical chemistry, the prospective works-chemist should also have some acquaintance with engineering, should understand the apparatus and machinery used in the particular manufacturing operations with which he is going to deal, and should have had practical experience in working the given process. . . . The arguments in favor of this view, that it is a hybrid chemist-engineer who is required in a chemical works, seem to me to be fundamentally unsound, and the kind of training suggested by them for the works-chemist can only result in the production of a sort of combined analytical machine and foreman. . . . We can not possibly expect such a poorly trained jack-of-all-trades to run a chemical works successfully in the face of competition directed by a large staff of scientific experts in chemistry and engineering.

These quotations are worth reading carefully; for they show two things: one, that I have not misrepresented Professor Kipping; and the other, that he has considered the situation with some care. But the quotations also show another thing, namely, that Professor Kipping has never been in active responsibility of a chemical works and really does not understand practical industry; and because of his own work and standing, his address may cause much hindrance and damage among the readers of SCIENCE. I venture to argue that the views of Professor Kipping are wrong; and that, in view of the necessities of American chemical engineering, at least, they are dangerous. What is needed is just this "combined analytical machine and foreman."

In discussing the broader relations of industrial education, Dr. Andrew S. Draper, state commissioner of education of New York, has most wisely pointed out the over-balance of intellectualism as compared with industrialism in our whole scheme of education; and this applies also with force and reason to our splendid system of training chemists in technical school, college and university. We are in no danger now—it may have been different twenty years ago—from the *practical* trenching on the *theoretical*. We have well-trained students of chemistry, trained in theory and research, by the hundreds; but they were started in a theoretical atmosphere, and they find exceeding difficulty in getting out of that atmosphere. These fine young students have information by the brainful, but they are "muscle-bound," to use the metaphor of an eminent professional athlete. And worse than that, these prodigies of academic training have not the faintest notion of how to *apply* one thousandth part of what they know in a merely intellectual way. What these graduates in chemistry might do if they could have learned the work-shop ideas of the *use*, the *need*, the *trouble*, the *remedy*—what they might do if they had some notion of this practical side, can be only surmised; but industrial necessities demand that the obvious gap in our system of chemical training be filled up without delay.

It must be noted that it takes all kinds of men to make a world. For one superintendent of a chemical works, there must be half a dozen foremen, and perhaps a dozen analysts and assayers; and it is desirable that every workman should know something of both the theory and practise of his trade. If a young man is content to plan for a subordinate position, as a mere analyst or research

chemist—and I should use the word, "mere," with care, especially when one recalls such assemblies of scholars as are gathered in such a research laboratory as that of the Badische Anilin-und-Soda Fabrik, but if a young man plans for such a position, the remarks of Professor Kipping may well apply. But that suits well with the conditions of the past; what we are concerned with is what touches the present needs.

One feature of American manufacture is the remarkable development of machinery and power application; and a great lack in this development is the very absence of what should be the chemical-engineering side of it. Now such a nation as Germany has both sides. Why should not America also have both sides? But the only way to reform is to reform; and now that we see the need, it is only necessary to follow in the path indicated. We have a store of well-trained chemists. We have a store of engineers. We lack the adequate supply of practical chemical engineers. It is easy to produce this needed supply—by teaching the chemist engineering; and by giving him teachers who have been and are in touch with the practical. Moreover, there is a great need of reforming the methods of teaching chemistry. With the safeguarding of the curriculum by employing men who know and respect theory, it is feasible to start the student with the practical idea; then he will never get away from it, he will see it always, he will love it and he will use it. For he will learn the dignity and worth of putting theory into overalls; and in turn he will learn the method and value of dressing practise with the dignity of theory.

CHARLES S. PALMER

NEWTONVILLE, MASS.

AURORAL DISPLAYS

IN the issue of SCIENCE dated July 10, I described a remarkable illumination of the sky at Sandy Hook, N. J., on the evening of March 27. Since that date I have witnessed two more sky glows, one on the night of August 18, and another on September 4. I had been quite prepared for further exhibitions of this kind, as a dispatch to the New York *Sun* from Washington, August 8, 1908, stated that there had been an unusual number of auroral displays or sky glows visible in Europe and the eastern part of the United States.

On August 18, I was at Murray Bay, Canada, on the lower St. Lawrence. The night of August 17–18 was cool, rainy and foggy. The afternoon of the eighteenth was windy and clear, and the evening was cool, calm and clear. The few days previous had been unusually warm. On the eighteenth, about 8 P.M., I first noted a rich glow in the west. This was followed, shortly afterwards, by the appearance of shafts spreading from about ten degrees north of west around by the north to almost due east. The illumination in some cases reached almost to the zenith. The shafts appeared and vanished with bewildering rapidity, and quite a number of spiral luminous clouds and persistent bright patches were visible. The illumination lasted until about ten o'clock. There was no moon, yet the general effect of the display was a diffused light about equal to that given by the moon at a quarter-phase.

The exhibition of the night of September 4 was noted at Fort Terry on Plum Island about ten miles from New London, Conn. The same succession in weather conditions had prevailed; hot weather followed by heavy rains, and clear cooler weather. The first indication was at 7:15 P.M., and consisted of a streamer about 60 degrees in length, rising from the horizon about ten degrees west of north. Other streamers in great number but much more attenuated appeared east of north. Some of these faded very quickly, to be followed by new ones, while others were quite persistent, and had a distinct motion towards the west. At about 8 o'clock a bright flat glow was noted almost due north, and shortly afterwards the northern illumination faded. At about 8:45 some peculiar striated luminous clouds appeared in the southwest, followed in turn by a few pale streamers due north. The display closed altogether about 9:30 P.M. It should be noted that the sky became somewhat cloudy towards the end of the display and

that the moon in the first quarter was unobscured by clouds most of the time.

Fort Terry, N. Y., W. E. Ellis
September 4, 1908

P. S.—Since furnishing the above, Mr. Donald Robertson, of Brooklyn, N. Y., writes me:

I saw another illumination last Friday, the fourth of September. I was at Lake Placid in the Adirondacks and had a fine view of it. It began at about eight o'clock and lasted until about nine or ten—I do not know which, as there was always a glow in the sky from eight to ten. In most respects, it resembled the one we saw at Murray Bay, but there was one difference. The heavens were lit up brighter than on August 18 and there were at times rainbow colors to be seen in the north.

I also wish to add that there was nothing in the displays of August 18 and September 4 that remotely resembled the steady eastern-western luminous patches of March 27. I am still of the opinion that the last was something more than an auroral exhibition.

Since writing my former account I have received several letters from scientists furnishing me opinions and latest explanations of auroral phenomena. The explanation that I advanced was not so much at variance with latest views.

In nearly all of the theories that have come to my notice, it is assumed that the sun is the only source of cathode rays, or the sun's action produces the cathode rays in our own atmosphere. The possibility that the earth may emit its own cathode rays does not appear to have been considered. W. E. Ellis

Fort Terry, N. Y.,
September 9, 1908

To the Editor of Science: In your issue of July 10 Mr. Wilmot E. Ellis refers to a remarkable case of illumination of the heavens which was observed in New Jersey on March 27 of this year. I was privileged to witness this same phenomenon from the uppermost deck of the R.M.S. *Adriatic* about 530 knots due east from Sandy Hook Light Ship. I had on several previous occasions observed spots or streaks of small dimensions in various parts of the northern heavens, sometimes rivaling in brightness the Milky Way itself, but never had I known of sky-brightness as extensive and as pronounced as I did in this case. The night was perfectly clear and Venus shone so brightly that a streak of light was thrown upon the surface of the ocean. I watched the phenomenon during the last twenty minutes of its manifestation, the general characteristics being as recorded by other observers, though I believe its general position was lower on the western horizon. I noticed no trembling whatever in the shafts of light which developed towards the last.

I can hardly agree with your correspondent as to the nature of this brightness. His theory is practically that proposed by Chaplain Jones, U.S.N., in 1855 for the zodiacal light. I do not pretend to deny a corona to the earth and moon, but if due to disintegration of matter, as Mr. Ellis suggests, it is evident that to allow for an applicable corona we should require a degree of ionization of the atmosphere close to the earth—apart from that due to sunlight—incomparably greater than what we observe.

I have long believed that sky-brightness was either due to an after-glow on banks of moisture or dust in the upper reaches of the atmosphere, or else to the burning of cosmic dust clouds as the earth's atmospheric mantle passed through them. These dusts might either be traveling in set orbits like meteorites, or more probably they would emanate from the sun, either as a continuous outgrowing corona, or likely enough as an intermittent discharge from spots. Sunspot areas are, if anything, hotter than the rest of the photosphere, which would be explained by the heat-retaining power of material dusts (probably gaseous in character) present in the direct line of bolometric measurement. The magnetic disturbances often observed shortly after sunspot eruptions would be explained by the bridging of space by these atomic dusts, and their effect as ions or carriers of electricity from the earth to the sun. The time elapsing between the eruption and the magnetic effects would indicate the speed of travel of these particles which might be compared with the growth of solar red-

flames. It is not difficult to reconcile a theory such as this with that of Arrhenius.

ALFRED SANG

RECESSIVE CHARACTERS

FOR the past two years there has been exhibited at the Trenton (New Jersey) Agricultural Show a cow without trace of the body hairs. This cow was crossed with a normal bull, according to the owner, Mr. Frank Fraunfelter, of Pennsylvania, and a male calf was born last September which has the ordinary hairy coat. This result indicates that the presence of the hair follicles is dominant over their absence. This adds another case to the law that the presence of a quality is dominant over its absence or that a retrogressive or retarded condition is recessive to the more developed conditions. C. B. DAVENPORT

QUOTATIONS

THE PRESIDENCY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE Institute of Technology has now solved a problem of some delicacy and difficulty in selecting for the head of that institution Professor Richard C. MacLaurin, at present at the head of the mathematical physics department of Columbia University, and he has accepted the honor and the responsibility. The institute has been under capable direction during the nearly two years that have elapsed since the resignation of President Pritchett. Acting President Noyes has maintained its high standards and manifested a degree of executive skill that probably would have given him the full title and lodged the full authority of the position in his hands had he been disposed to accept them. But his chosen field of chemical research has possessed more attractions for him. In it he has opportunity to blaze new trails in scientific advance, and he is to be commended for his clear and loyal following of his own light and leading in this matter.

The new president evidently understands in its general features the nature of the work to which he has been called, and his record in educational service indicates that he is one who readily becomes master of detail. The experience will be not less new to him than to the institution, which now for the first time will be under the direction of a man born in another country and trained in foreign schools and universities. That is not necessarily an objection. It may prove a positive gain. Professor MacLaurin is a comparatively young man. His attainments are more than excellent; they are extraordinary, and few men of his years have won more flattering recognition from sources that bear the stamp of authority.

Of course, mere scholarship, even of the highest order, is not enough to meet all the requirements of this new responsibility. His executive ability and his adaptability can be proved only by actual service. But Scotch scholars are thorough; their standards are high and shrewdness and personal tact are among their national characteristics. When Princeton called Dr. McCosh to the presidency, he was a man well along in years, but a famous metaphysician, and he filled the place with distinction. The institute does not need metaphysicians, and the new president has not turned his researches in that direction. He has made great advances in modern science; he is learned in the principles of law and is undoubtedly an enthusiast with respect to the various lines of research with which he has been so conspicuously identified. The institute authorities, the alumni and the public have a well-grounded hope that under his administration a new era of prosperous service will open up for this famous school.—*The Boston Transcript.*

BURDENS OF COLLEGE PRESIDENTS

PRESIDENT ELIOT'S impending retirement from the presidency of Harvard is bound to give an impetus to the movement to divide the functions of that office. "The governing boards and the alumni will understand better in six months than they do even now what a void Eliot will leave," writes one of the most prominent of the Boston alumni. But this is not only because Mr. Eliot towers above all other college presidents and is the foremost American citizen. The magnitude of his office is such that it would be a most difficult

task to fill it, had it been held by a man of far smaller intellectual calibre. The administrative work alone would tax the abilities of our greatest corporation heads, while the outlining of its courses of study calls for educational statesmanship of the first rank. . . .

In President Eliot's case, he has borne the multifarious burdens, including the duty of meeting with the governing bodies and the faculty, at the expense, we are tempted to say, of the student body. By this we mean no criticism; it is a fact, however, that he has generally been a stranger, or a great name, to the undergraduate body. Close relations with it have been humanly impossible; all one could ask was the necessary intercourse with the leaders of the teaching staff of *only* 566 persons. So when one of the leading undergraduates was asked by a reporter the opinion of that body as to the president's retirement, he naïvely answered to the effect that "few of us know him, but all regret the change"! True, Mr. Eliot has for some years past annually met the newly entering class with one of those exquisite addresses of counsel and inspiration that will have high place among the enduring monuments he has, unconsciously enough, builded to himself. But beyond that the influence of his noble personality and his lofty personal life have penetrated to the undergraduate hardly more than to the general public all over the country. This has been a grave loss to college and nation, for the moulding of character is, after all, the primary duty of a university; even of a teacher of science, as Professor Arthur A. Noyes of the Institute of Technology admirably points out in the current SCIENCE. "To begin with," he says, "we [the teachers] set him [the student] the example of rendering unselfish service to others by giving him individual aid. . . ." And it is individual moral aid that the Harvard student often so sadly lacks. Who in our time has been better fitted to extend it than President Eliot?

Then there is the faculty. It takes a great general to inspire 566 teachers; to recruit their forces, to recognize the worthy and discard the drones or the inefficient; to lead them on over the breastworks of tradition to new fields of honor and of service. That would seem in itself to be a sufficient life's work for any one man. And so we confess to having been surprised to learn last year that a majority of a joint committee of the Overseers and the corporation, including President Eliot, found, after inquiry, that "the president of the university does not need to be relieved of any function that he now performs; but that he ought to be relieved of details in many directions, and to have more assistance than he now has." Would they have been able to report the same with any one else as president? Will the governing boards not yet come to filling President Eliot's place with two men, one a rector in charge of everything pertaining to the scholastic work, the students, and the teachers, and the other a man of the type of the late William H. Baldwin, Jr., of the Long Island Railway, of marked business ability, of winning and upright personality—qualified to represent the university in all of its relations to the public and the nation?—New York *Evening Post.*

SCIENTIFIC BOOKS

First Course in Biology. By L. H. BAILEY and W. M. COLEMAN. New York, The Macmillan Co. 1908.

The present work is divided into three parts, the first of which is devoted to botany and is written by Professor Bailey, while the second and third parts dealing respectively with zoology and physiology are by Professor Coleman. As is remarked in the preface, there is a tendency in secondary education to introduce unit courses in biology in place of isolated courses in botany, zoology and physiology, and the authors have aimed to prepare a book which presents the elements of biology as exemplified by plants, animals and man, rather than separate treatises on different fields of biological science. The book is designed to afford material for three half years, but the ground may be covered in a single year by omitting the matter in fine print.

There is a useful introductory chapter on the elementary facts of chemistry which are essential for the understanding of the bio-

logical discussions which follow. Then the student is plunged at once into accounts of variation, struggle for existence, survival of the fit, and plant societies—topics which more frequently form the end, instead of the beginning, of text-books, although as here presented they can readily be grasped by the beginning student and may serve to enliven his interest in and appreciation of what is to come. Most of the botanical section is devoted to the structure, physiology and adaptations of flowering plants, the cryptogams being dealt with in the last chapter in fine print which is designed to be omitted should time not be adequate for the complete course. Many teachers may criticize the limitation of the work so largely to the flowering plants and the inadequate conception it gives of the diversity and general development of the vegetable kingdom. One must of necessity sacrifice important subjects in an elementary text, and it is quite natural that the writer who stands so prominent as an authority in horticulture and agriculture should emphasize, perhaps unduly, those parts of the subject which are more directly concerned with these branches. Professor Bailey has brought the student more closely in touch with the practical aspects of botany than is usually done, and this is a valuable feature of his part of the book, even from the standpoint of the teacher of pure science. The text is clearly written and illustrated with many good figures most of which are new, and there are lists of questions and helpful suggestions for work at the close of the various chapters.

The zoological part of the work suffers considerably in comparison with the preceding. Errors are numerous and frequently serious, while there are many more statements which are misleading or inadequate. Space will not permit us to point these out in detail, but the following will serve to indicate sufficiently, I think, the general character of the work. After describing *Amœba* and *Paramœcium* we have the statement: "Other classes of Protozoans are the infusorians, which have many waving cilia (Fig. 17) or one whip-like flagellum (Fig. 18), and the foraminifers which possess a calcareous shell pierced with holes (Fig. 19)." In the first place the infusorians do not, as the statement implies, form another class in addition to that represented by *Paramœcium,* they do not in most recent systems of classification and certainly should not include the flagellata, many of which have two or more flagella instead of one; nor are the foraminifera ranked as another class distinct from the rhizopods to which *Amœba* belongs, but as a subordinate division of the same group; they do not all possess a calcareous shell; in large numbers of species the shell is not pierced with holes; and the figure which is supposed to represent one of them is a picture of a radiolarian!

In Fig. 23 what are called the eggs of the fresh-water sponge are doubtless the gemmules. After informing us that in sponges "the ciliated cells and the reproductive cells are the only specialized cells," and that "slow-growing sponges grow more at the top and form tall, simple, tubular or vase-like animals. Fast-growing sponges grow on all sides at once and form a complicated system of canals, pores, and oscula," we are given an illuminating account of how sponges may have arisen from unicellular ancestors.

> Several one-celled animals happened to live side by side; each possessed a thread-like flagellum or whip-lash for striking the water. By lashing the water they caused a stronger current than protozoans living singly could cause. Thus they obtained more food and multiplied more rapidly than those living alone. The habit of working together left its impress on the cells and was transmitted by inheritance. Cell joined to cell formed a ring; ring joined to ring formed a tube which was still more effective than a ring in lashing the water into a current and bringing fresh food (particles of dead plants and animals) and oxygen.

Comments are superfluous.

In the description of the nettling cells of hydra the fact is announced that after their discharge "when the pressure is withdrawn the thread goes back as the finger of a glove may be turned back into the glove by turning the finger outside in." In the same chapter occurs also the misstatement that "the hydra is the only fresh-water representative" of the "branch polyps (sometimes called Cœlen-

terata)." And the figure of hydras on pondweed is inverted, giving one the impression that animals are growing on the stems up in the air.

In the chapter on Echinoderms the following sentences are from one point of view very instructive: "The sand dollars are lighter colored than the sea urchin. Why?" Here the bright pupil is probably expected to hold up his hand and, without ever having seen a sand dollar, much less observed one in its natural habitat, explain the matter, after the common fashion, as a case of protective coloration. The explanation fits the case all the better if it is not known that many species of sand dollars when alive in the water and still containing a large amount of purple pigment are anything but light colored and do not become so until they are bleached out or denuded of spines or both. "Starfish," the author tells us, "are brown or yellow. This makes them inconspicuous on the brown rocks or yellow sands of the seashore." In this as in several other cases the author seems naïvely unaware of the danger of making general statements on the basis of a few instances. Only a slight investigation of the colors of different starfish would make him acquainted with species of red, orange, purple or other color of the most conspicuous kind, and would doubtless have shaken his faith in the general occurrence of protective coloration in this group. The flat form and light thin walls of the sand dollars are explained as an adaptation to prevent their sinking into the sand. This may be the case, but the author is a little venturesome when he relates that "the five-holed sand cake or sand dollar has its weight still further diminished by the holes, which also allow it to rise more easily through the water." Whether he conceives these creatures to have the faculty of rising and swimming about like fishes is not entirely clear, but the possession of some means of locomotion above the bottom seems to be implied.

In regard to the common earthworm whose structure is correctly described in so many text-books it is surprising to find the author falling into several errors. The eggs are said, on page 46, to pass out of two pairs of openings in the fourteenth and fifteenth segments, while on page 47 they are said to pass into the collar-like case as it passes the fifteenth and sixteenth segments—two contradictory statements, neither of which is correct. A structure marked *ES* in Fig. 77 is called egg gland, while other bodies marked o_1 and o occurring in the twelfth and thirteenth segments respectively are not given any further explanation. The word clitellum is employed for the chitinous capsule which surrounds the eggs instead of the glandular region of the body by which the capsule is secreted.

After warning us that "the name 'worm' is often carelessly applied" and that it should be given "only to segmented animals without jointed appendages" we are given a classification of the "four classes in the branch Vermes," two classes of which, the roundworms and the rotifers, are not segmented forms at all, while in the third class, the flatworms, segmented forms occur only in one of the subordinate divisions. The first class is designated "*earthworms,* including sandworms and leeches," which is something of a sacrifice of accuracy to simplicity of terminology.

On page 79 we meet with the statement that:

> It is probable that the large or compound eyes of insects only serve to distinguish bright objects from dark objects. The simple eyes afford distinct images of objects within a few inches of the eye.

It would be difficult to give an account more at variance with the facts, and we recommend the perusal of Forel's "Expériences sur les Sensations des Insectes" before the issue of a second edition. On the same page occurs a section upon "Inherited Habit or Instinct," in which the mode of origin of instincts is described and summarized in the sentence "Repeated acts constitute a habit, and an inherited habit is called an instinct." We do not criticize the writer for espousing a view of the origin of instincts now largely discredited and accepted by practically none in the unqualified form here set forth, but if the subject is discussed at all the student should not be given but one interpretation and taught dogmatically that it is the correct one. The table for classi-

fying insects on page 82 contains many errors; statements either the reverse of the truth or otherwise faulty occur in six out of the ten short diagnoses of the orders.

The inaccuracies, of which many more examples could be pointed out, are not the only features that call for criticism. They constitute rather a symptom of debility in other directions. Students of science will gain little profit from a book in which there is a lack of clearness and cogency of thought, and the choice of the text in its present condition for a class in zoology would be one to be deplored.

In dealing with physiology the author is apparently more at home. At least there are fewer errors. There is, however, a very inaccurate original diagram of the sympathetic nervous system, and there are several statements that require emendation. The outlines for practical laboratory experiments form a commendable feature of this part of the work, and the general plan of having physiology follow a course in zoology leading gradually up to the study of man is an excellent one, but it is regrettable that it should have fallen so far short of the ideal in its execution.

S. J. H.

Typhoid Fever. Its Causation, Transmission and Prevention. By GEORGE C. WHIPPLE, Consulting Engineer. With an Introductory Essay by WILLIAM T. SEDGWICK, Professor of Biology, Massachusetts Institute of Technology. New York, John Wiley and Sons; London, Chapman and Hall, Limited. 1908.

The publication of a work by a layman on a subject usually regarded as medical is something of an innovation, and a welcome one. It is curious that the preventable diseases, which from the prophylactic standpoint present so many aspects of a technical, but not a purely medical, character, have not been discussed more frequently by sanitarians in works, like this of Mr. Whipple, which are in a form which commends them to the general reading public. The medical profession has often been accused, and justly so, of being too secretive regarding medical affairs. There is an undoubted and salutary reaction within the profession against this policy of secretiveness, and books like Mr. Whipple's will help along this reaction.

Mr. Whipple's work does not go into details regarding the purely clinical aspects of typhoid fever, but merely sketches this side of the disease, and relates for the most part, as the subtitle indicates, to the causation, transmission and prevention of the disease. These subjects are covered in a series of chapters dealing with the life history of the typhoid bacillus within and without the body, the lines of defense against its entrance, statistics dealing with the distribution and epidemiology of the disease, its relation to water supplies, and a brief chapter on the financial loss caused by its prevalence. Useful appendices deal with the use of disinfectants, the rôle of house flies in the spread of the disease, death rates, water analysis, the viability of the germ, and the literature of the subject. The book is well printed, and is admirably illustrated by numerous charts, and an ingenious frontispiece which shows the methods of transmission and means of protection.

The work differs from most of those available to the public in the simplicity of its language, which can be understood by any intelligent layman. It differs from most medical treatises on Typhoid Fever in the emphasis placed on the transmission and prevention of the disease, and in the wealth of statistical detail available to support the various statements. We could have wished that there was more in the book concerning what has actually been accomplished in the prevention of the disease when due to contact rather than water or food transmission. Koch's work at Trier, which shows what can be done to stamp out the disease under certain circumstances, might have been quoted. Though Mr. Whipple's profession naturally impresses upon him most forcibly the dangers of water and food transmission, he recognizes the importance of contact, but does not, we believe, emphasize it so forcibly as is desirable. In the main the work is an admirable one, and worthy of the highest commendation. Professor Sedgwick's introduction is an interesting historical summary of the development of our knowledge of the disease.

GEORGE BLUMER

SPECIAL ARTICLES

NOTE ON THE FORMULAS FOR ENERGY STORED IN ELECTRIC AND MAGNETIC FIELDS

Consider a charged sphere. Let it grow in size. The potential decreases for the same charge as the radius increases. Hence the potential energy also decreases. The tubes of force, everywhere pulling the surface out toward infinity, are losing the potential energy of their stretched condition, and at infinity they have closed up and the potential energy has disappeared from the potential state.

We may then consider the energy as residing, not in the sphere but in the dielectric outside, and that the amount of energy that disappears from the potential state at each step is entirely in the spherical shell of the dielectric, which makes up the difference in volume between the successive steps in the growth of the sphere. We have then, only to calculate the difference in potential energy for two slightly different radii of the sphere and divide by the volume of the spherical shell, and we shall have the density of the energy in the electric field. It is to be noted that the electric field at any point outside the sphere is unchanged by the growth of the sphere, since the number of tubes of force, and hence the amount of their crowding, depends only on the charge and not on the size of the sphere.

Let r be the radius of the sphere, v the volume, e the charge, E the electric field, ψ the potential, P the potential energy, ϵ the dielectric constant.

By definition ψ is the work necessary to carry unit charge from infinity to the sphere, or

$$\psi = \int_{\infty}^{r} E dr = \int_{\infty}^{r} (e/r^2) dr = e/r, \qquad (1)$$

which might have been written immediately, since the capacity of a sphere is r. Also by definition

$$E = d\psi/dr = d/dr\,(e/r) = e/r^2. \qquad (2)$$

We have also

$$P = \tfrac{1}{2}\psi e. \qquad (3)$$

From (1) and (3),

$$P = e^2/2r.$$

Differentiating, we get the change in potential energy due to a small change in radius,

$$dP = -e^2 dr/2r^2,$$

the negative sign meaning a decrease in energy for an increase in radius. The volume of the shell is $4\pi r^2 dr$, and the loss of potential energy per cm^3 is, by equation (2),

$$dP/dv = -e^2/8\pi r^4 = -E^2/8\pi.$$

Hence the energy in the dielectric is $E^2/8\pi$ ergs per cm^3.

If $\epsilon \neq 1$, the charge for the same ψ and the same E is greater and we have to write $\epsilon\psi$ and (ϵE) instead of ψ and E in equations (1) and (2), to make them hold numerically. This followed through gives, finally,

$$E(\epsilon E)/8\pi.$$

The expression for the energy in a magnetic field follows in exactly the same way; we have only to substitute m for e and H for E in the equations above. We may take a sphere of very great permeability as an isolated pole m. Should it seem clearer, this sphere may be thought of as the pole piece of a long magnet of infinitesimal diameter reaching to infinity, where the other pole piece forms another spherical shell. The tubes of force tend to shorten as in the electrostatic field, closing up when the sphere grows to infinite radius.

The energy per cm^3 comes out $H^2/8\pi$.

If all surrounding space is filled with a medium whose permeability is μ instead of *1*, the number of tubes for the same H is μ times as great. So, as before, we must use $\mu\psi$ and (μH) in equations (1) and (2), which, traced through, give $H(\mu H)/8\pi$ ergs per cm^3.

The first three derivations are rigorous, but awkward questions arise as to what the H and the B, in the last case, represent physically. Yet it can be made satisfactory by supposing that the long thin magnet is divided into two parts, one supplying H tubes of force, and the other supplying $(\mu - 1)$ H tubes, the former being rigidly magnetized.

From the method of this derivation it follows without additional proof that the tension along the lines of force is numerically equal to the energy density.

P. G. Agnew

Washington, D. C.

A VACUUM STOPCOCK

DURING the winter of 1908 work was undertaken on the gas production of *Bacillus coli* in synthetic culture media. The method of work consisted of growing the organism in high vacuum. In the course of this work considerable difficulty was experienced in maintaining absolutely tight stopcocks and as a result a stopcock was devised that appears to satisfy the conditions for a gas-tight stopcock.

The ordinary stopcocks had to be reground with jeweler's rouge, and while this precaution rendered the stopcock gas-tight under constant temperature conditions, it was found that the changes in temperature from room to incubator caused the two ground surfaces, assisted by the resilience of the lubricant, to separate and thus make the stopcock leak. To overcome these difficulties the stopcock had to be tied into place and mercury placed in the exposed lead.

The stopcock devised to overcome these difficulties is explained by the two diagrams. The passage from X to Y leads through an obliquely drilled plug as in the ordinary improved vacuum stopcock. At A a small bulb takes the place of the ordinary open end. Into the center of the plug, and in the same plane as the oblique drilling, a drilling is made as far as the level of the lead X. From

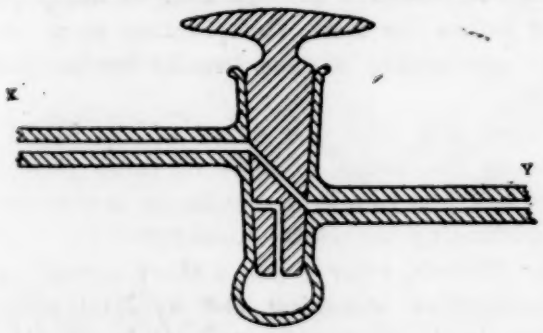

FIG. 1

this point it continues at a right angle as indicated in the diagram. The operation of the stopcock is as follows. The stopcock being in the position indicated in Fig. 1, the plug is turned through 180°, thus bringing it into the position indicated in Fig. 2. The stopcock is then connected with the pump and the small bulb exhausted. Turning the plug through another 180° will open the passage from X to Y and then it may be opened and closed at will without the small bulb A ever coming into communication with the passage.

In the above arrangement the atmosphere is exerting its pressure to hold the plug in place, thus overcoming the resilience of the

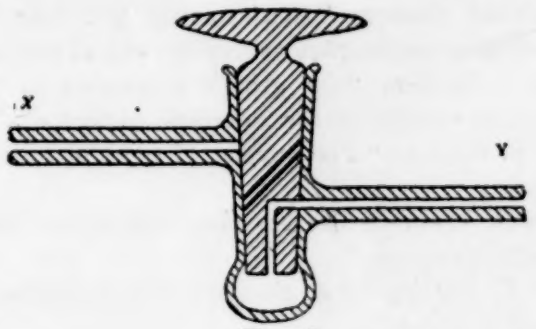

FIG. 2

lubricant and pressing the two ground surfaces together constantly, in spite of the temperature changes that tend to let one surface expand away from the other. The lubricant is composed of gutta-percha, hard paraffin wax and a heavy mineral oil; and answers admirably. Many similar lubricants are described in the literature.

The above stopcocks were very neatly constructed by Eimer and Amend.

BROWN UNIVERSITY FREDERICK G. KEYES

SOCIETIES AND ACADEMIES

THE AMERICAN MATHEMATICAL SOCIETY

THE one hundred and fortieth regular meeting of the society was held at Columbia University on Saturday, October 31. A single morning session sufficed for the brief program. The president of the society, Professor H. S. White, occupied the chair. The attendance included twenty-one members. The following new members were elected: Professor J. A. Brewster, St. Angela's College; Professor W. H. Butts, University of Michigan; Dr. C. F. Craig, Cornell University; Professor T. A. Martin, Mt. Union College; Professor M. T. Peed, Emory College; Mr. G. E. Roosevelt, New York City; Mr. L. M. Saxton, College of the City of New York. Four applications for membership were received. The total membership of the society is now 605.

A list of nominations of officers and other members of the council was adopted and ordered placed on the official ballot for the annual election at the December meeting. It was decided to hold the annual meeting at Baltimore, on Wednesday and Thursday, December 30–31, in affiliation with

the American Association for the Advancement of Science.

The following papers were read at this meeting:

R. D. Carmichael: "On the theory of functions of a triple variable."

R. D. Carmichael: "Notes on the simplex theory of numbers."

Edward Kasner: "Conformality and functions of two or more complex variables (second paper)."

G. A. Miller: "On groups generated by two operators satisfying the equation $s_1 s_2 = s_2 s_1$."

E. B. Wilson: "The number of types of collineations."

Frank Irwin: "The invariants of linear differential expressions."

A. E. Landry: "A geometrical application of binary syzygies."

The Southwestern Section of the society will hold its second regular meeting at the University of Kansas, on Saturday, November 28. The Chicago Section will meet at the University of Chicago on Friday and Saturday, January 1–2.

At the annual meeting of the society at Baltimore President White will deliver his retiring address on "Bezout's theory of resultants and its influence on geometry." F. N. Cole,

Secretary

THE AMERICAN CHEMICAL SOCIETY
NEW YORK SECTION

The second regular meeting of the session of 1908–9 was held at the Chemists' Club on November 6.

The Nichols medal, awarded annually for the best paper read before the section, was presented to W. A. Noyes and H. C. P. Weber for their paper on "The Atomic Weight of Chlorine."

Dr. L. H. Baekeland, chairman of the section, spoke as follows:

"A few years ago our distinguished fellow member, Dr. W. H. Nichols, donated to this section of our society a fund wherewith to offer a gold medal every year for the best paper read at our meetings.

"I remember that, when this generous offer was made, I felt somewhat uncertain about the ultimate result. I knew that in this country of unbounded generosity it was easy to find a warm-hearted donor; I knew that it was easy enough to find an artist to make the medal an undoubted work of art; but I knew also that the Nichols medal would only be consecrated to its proper value, not in relation to the amount of gold it contains, nor in relation to its artistic value, but solely and exclusively by the quality of the work rewarded by it.

"Last year our section was unusually fortunate in the variety and the quality of the papers which were read before its meetings.

"Among several excellent papers, four attracted special attention:

"'The Atomic Weight of Chlorine,' H. C. P. Weber and W. A. Noyes.

"'The Extraction of Potash from Feldspathic Rocks,' A. S. Cushman.

"'The Ignition Temperature of Gaseous Mixtures,' K. G. Falk.

"'Drop Weights and the Law of Tate. The Determination of the Molecular Weight in the Liquid State by the Law of Tate,' J. L. R. Morgan and Reston Stevenson.

"Every one of these papers was fully worthy of the Nichols medal. Yet it was the general verdict as decided by vote that the paper of Weber and Noyes should be classed first.

"When I wrote to these gentlemen the announcement of the result, they acknowledged my letter and showed their equanimity by stating that they would have considered it an honor even if their work had been classed second to the three other excellent papers.

"To those here present who remember the struggling times of our society, when not so many years ago it was hard to get a dozen of us together at a meeting; when original research work in America was very scarce and weak in almost all departments of science, it certainly must appear as an inspiring symptom of fully awakened scientific activity that so many papers read before the New York Section alone should have been worthy of consideration for the Nichols prize.

"And now that the donor of the medal has done us the honor to-night of being among us, I request him to add to the luster of the occasion by presenting the medal himself."

Dr. Nichols, after giving a short account of the circumstances attending the foundation of the medal fund, presented the medals to the two successful autnors.

Dr. Noyes in reply expressed the appreciation of himself and Dr. Weber of the honor conferred upon them and gave a brief résumé of the prize paper. He was followed by Dr. Weber, who spoke of some further work along the same lines on the atomic weight of bromine.

The remainder of the evening was devoted to a paper by Dr. J. E. Teeple on "An Enzyme Splitting Sugar into Acids." C. M. Joyce,

Secretary